A MANUAL of Naval Hygiene

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PREPARED BY

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FOREWORD

Sanitary and hygienic problems of air and of land, of surface and of subsurface craft present themselves daily to the medical officer of the Navy. Air constituents and pressures, arctic and tropical temperatures and humidities, food and water, clothing, lighting, these and many other facets are as much the care and consideration of the naval surgeon as are the diseases and wounds of the personnel in sickness and in battle.

And yet the field of naval hygiene is a sparsely covered one as far as textbooks are concerned. It is in response to this need that a number of officers of the Medical Department have collaborated with me in the preparation of this volume. To them I extend my sincere appreciation and thanks.

Ross T McIntire,
Surgeon General,
United States Navy.

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Chapter I

THE SHIP AS A LIVING SPACE AND THE INFLUENCE OF NAVAL ARCHITECTURE ON NAVAL HYGIENE

Man's power of adaptation to all sorts of living conditions is nowhere more fully shown than in his ability to live on shipboard, both in surface ships and in submarines, as well as in his adaptation to life in aircraft.

In the ship there must be air, fresh water, light, heat, food, provision for the removal of wastes, for rest and recreation, and the care of the sick and injured. All of these requirements must be met if the ship is to fulfill its primary mission. These matters and many others related to them form the subject of nautical or naval hygiene. It is apparent that these questions have varied with changes in the type, size, and construction of ships.

The first change in naval architecture which produced a profound effect on naval hygiene was the change from oars to sail. This permitted the building of larger vessels with several decks and consequently greater seaworthiness and ability to make longer ocean voyages. As a consequence, questions of ventilation, the preservation of food, and the supply of fresh water became important matters. Long voyages were responsible for diseases resulting from overcrowding; others due to food deficiencies, such as scurvy, and contact with the Tropics and tropical diseases.

The change from sail to steam resulted in the shortening of the voyage, provisions for the manufacture of water by distillation, power-driven ventilation, the refrigeration of foods, and improved heating and lighting.

Perhaps one of the most important changes was that from wooden construction to iron and steel. This change did away with the leaking through the seams of the old wooden vessels and with the resulting dampness prevalent in wooden ships, the virtual elimination of vermin, and greater ease in keeping the vessel clean. Rats, mice, and cockroaches tended to disappear on the metal ships, as the absence of food and water in the compartments led to their death. The water-tight steel compartments of the modern ship contain no water, and even if a rat were to enter a compartment containing food the absence of water would result in his death. The only great disadvantage of the metal ship as a living space in contrast to the wooden vessel is the high conductivity of metal to heat or cold. This makes the steel ship cold in winter and hot in summer, hence the development of measures to control the temperature in living spaces and the indirect improvements in naval hygiene in this respect. The need for temperature control was also made necessary by the presence of the so-called "wild heat" on steam-driven vessels. This is the term used to describe the heat radiated by boilers, engines, dynamos, as well as bakeries, laundries, and similar places. The necessity for controlling this "wild heat" has also led to many improvements in naval hygiene.

Special problems in preventive medicine and naval hygiene appeared with the development of the submarine, the closed-cabin airplane, and various types of

naval vessels such as the destroyer, the aircraft carrier, and the small, fast torpedo boat. Changes in size and design of these vessels and the possible development of new types of ships will continue to bring new problems and to exercise the ingenuity of the naval hygienist.

Chapter II

VENTILATION AND AIR CONDITIONING ON SHIPBOARD

The medical officer is responsible for the maintenance of the health of personnel. Since air conditions constitute one of the most important factors affecting health aboard ship, the medical officer is called upon to define the proper air environment. Essentially on the basis of physiologic knowledge, he must be able to state the criteria that govern not only good air conditions but he must also be able to gage the limits of tolerance for unavoidable deleterious atmospheres.

In practice, the medical officer will seek *to maintain an ideal atmospheric state*, while the engineer is compelled by military considerations to provide only the minimal ventilation consistent with the welfare of personnel. A balance therefore, must frequently be struck between divergent objectives.

The task, however, of the medical officer is clearly defined. It is to supply the engineer with quantitative data; to report on the environment in terms of temperature, moisture content, air movement, and radiant heat; to record physiologic data in terms of pulse rate, body temperature (mouth, envelope of skin, and the foot-shoe temperatures) and subjective reactions based on a fixed sensation scale.

The Purpose of Ventilation, Heating, and Cooling.

The Air Conditioning Section of the Bureau of Ships has cognizance over matters of material pertaining to ventilation. The Bureau of Ships Manual states:

> The weight added, the space occupied, and the power consumed by the ventilation, heating, and cooling arrangements on a naval vessel must be at the expense of other military necessities. The minimum of equipment is provided which will accomplish the following purposes:
>
> (*a*) To maintain, in the living spaces and normally occupied parts of the vessel, conditions which will keep personnel fit to fight under the strain of frequent watches during prolonged wartime cruising.
>
> (*b*) To maintain at battle stations and in working spaces conditions which will keep personnel physically fit to fight and mentally keen under the circumstances when such spaces must be occupied during war.
>
> (*c*) To maintain in certain spaces containing equipment or material, the conditions necessitated by the presence of that equipment or material.
>
> Basically the environment must be such that the body can maintain a proper heat balance and the chemical composition of the air must be such that it contains no harmful components and provides a sufficient quantity of oxygen.

The factors to be considered in the air environment are temperature, humidity, air motion, odors, bacteria, the oxygen and carbon-dioxide contents and harmful agents such as smoke and carbon monoxide.

It is the rapid shift, however, from one type of climatic environment to another that subjects personnel, unaided either by adequate clothing or by artificial heating or cooling, to severe hardships.

The structure of the warship further complicates the problem. To supply outside air to a craft catacombed with watertight compartments without weakening the

flotation power of the ship provides the naval engineer with one of his most difficult problems. In addition the steel structure, for the most part deprived of insulation, is subject to high surface temperature not only from the sun's rays, but from heat emitted from machinery spaces.

Natural ventilation in the sense of utilizing open ports is therefore not feasible, since the modern ship presents a sealed hull 15 to 30 feet or more above the water line. The tremendous heat loads, moreover, emanating from machinery spaces must be removed primarily by a continuous supply of fresh air.

Blowers, both supply and exhaust, are required to pump air into and out of compartments, ducts to carry the air to the various compartments, and terminals of various types to distribute it to best advantage. In cold weather heaters are needed, in warm weather bracket fans facilitate heat loss from the body.

At sea, outside air temperatures in naval operating areas are determined by the temperature of the sea water, 29° to 85° F., seldom exceeding a range of from 10° to 88° F.

Within the ship we are concerned with essentially two types of spaces. There is the *hot dry space*, in which the primary objective is removal of heat created by the operation of machinery. Temperatures of 110° to 120° F., dry bulb, and 80° to 84° F., wet bulb, may prevail in this type of space which is usually provided with facilities for spot-cooling. On the other hand, there is the *hot wet space*, a sealed or partially sealed space in which the removal of moisture from personnel is the essential problem. In such spaces the dry-bulb temperature may not exceed 90° to 95° F., but the wet-

bulb temperature may be above 85° F., creating an atmosphere that is especially debilitating. In the hot dry space the factor of radiant heat means that both machinery and personnel require insulation.

The concept of effective temperature enables us to resolve the variable factors of temperature, humidity, and air motion into a single index to indicate the degree of warmth perceived by the body.

As a result of experiments made on a large number of human subjects it was found that the same subjective degree of warmth induced, for example, by an atmosphere saturated with moisture at 80° F. could be maintained at various combinations of wet-and-dry-bulb temperatures. Lines joining points on the psychrometric chart indicative of wet-and-dry-bulb temperatures imparting the similar sensations of warmth are called *effective temperature lines.*

The following air conditions, for example, each at 90° effective temperature, are considered to be equivalent in their warmth-giving properties: 90° dry bulb and 100 percent relative humidity, 105° dry bulb and 50 percent relative humidity, 120° dry bulb and 20 percent relative humidity, and 135° dry bulb in perfectly dry air or zero percent relative humidity.

For still air, that is an air velocity less than 30 cubic feet per minute, figure No. 1 shows the relationship between dry-bulb, wet-bulb, and effective temperatures.

Moving air lowers the effective temperature for a given temperature and humidity as indicated in figure No. 2.

For a saturated atmosphere and an effective temperature equal to skin temperature (95° F.), air movement gives no cooling. For this condition there is no heat

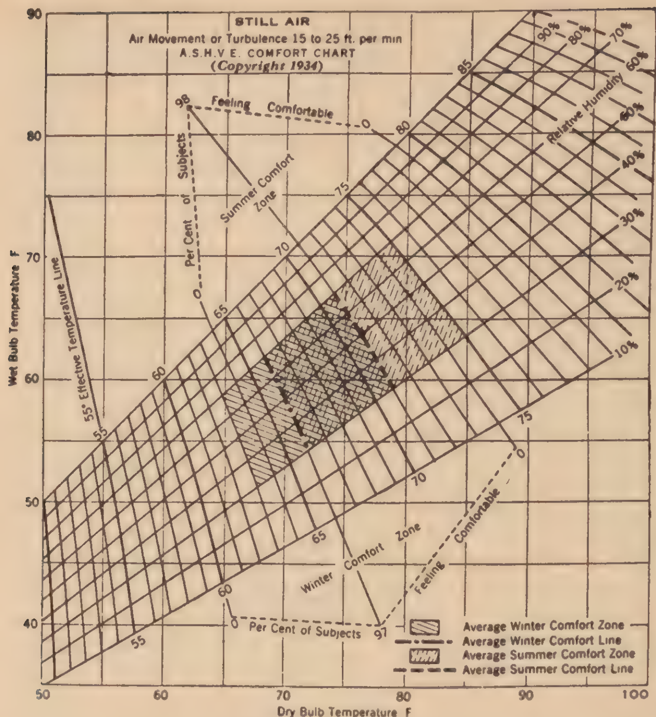


FIGURE 1.—A. S. H. V. E.[1] comfort chart for air velocities of 15 to 25 F. P. M. (still air). Both summer and winter comfort zones apply to inhabitants of the United States only. Application of winter comfort line is further limited to rooms heated by central station systems of the convection type. The line does not apply to rooms heated by radiant methods. Application of summer comfort line is limited to homes, offices, and the like, where the occupants become fully adapted to the artificial air conditions. The line does not apply to theaters, department stores, and the like where the exposure is less than 3 hours.

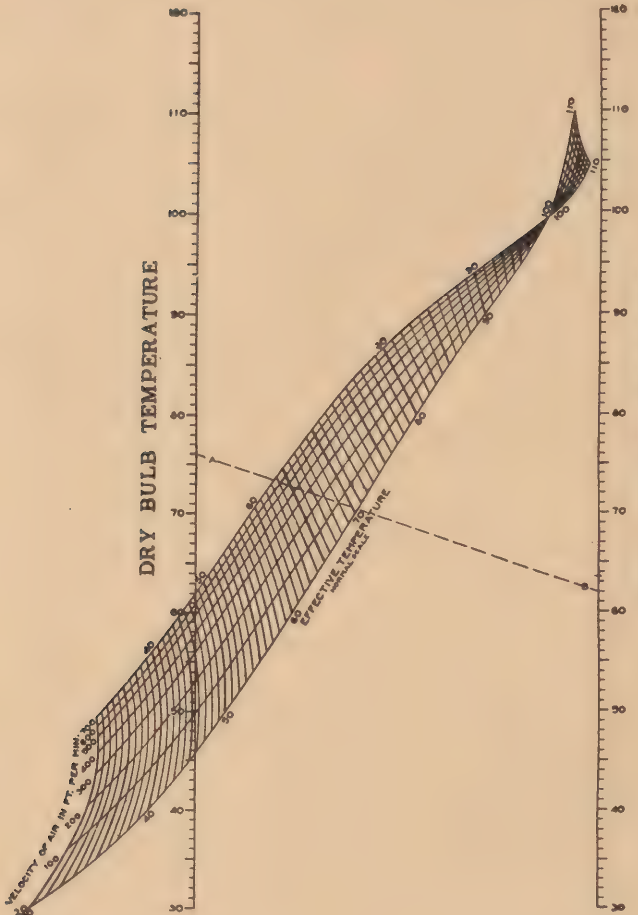
[1] American Society of Heating and Ventilating Engineers.

loss by either convection or evaporation, either with or without air movement. For hotter conditions and the same moisture content, air velocity makes the individual feel hotter.

At lower temperatures the cooling effect of air motion increases progressively so that at 60° F. saturated air at a velocity of 100 feet per minute gives a sense of cooling equivalent to the lowering of the dry-bulb temperature by 3° F.

Comfort zones are given in the shaded areas in the effective temperature chart (fig. No. 1) and are zones in which 50 percent or more of the people who were subjects in the tests expressed themselves as feeling comfortable. It will be noted that the zones extend from 70 to 30 percent relative humidity. It is recognized that extremely low humidities are not comfortable and that they may be conducive to respiratory infection in winter. Practical considerations, such as the prevalence of condensation on walls and windows, limit the humidity which may be used in cold weather to low percentages. Single glazed windows in a room at 70° F. air temperature with 30 percent relative humidity will condense water vapor when the outside temperature reaches a value of approximately 38° F.

Limitations of the effective temperature chart relate to conditions where radiation is not a factor. The experiments were made in rooms having no source of radiant heat, since the walls of the rooms were substantially at the dry-bulb air temperature. The winter condition in most rooms only roughly approximates this situation as there is often some radiation from heating units and usually some cold wall or window surfaces to which the bodies of the occupants



(Legend for Figure 2 on opposite page.)

radiate heat. The chart therefore must be interpreted as omitting the *factor of radiant heat which frequently is of great importance in the hot spaces aboard ship.*

The upper limits of desirable air conditions are based upon shipboard test. Temperatures in the range of 77° to 83° dry-bulb with respective relative humidity values of 80 to 50 percent, will be associated with heat loss from the body without visible sweating. That is to say, about 60 percent of the heat loss will be brought about by radiation and convection, and 20 to 40 percent by the evaporation of insensible perspiration.

These values represent the upper limit of air conditions for comfort. Consideration, however, has been given to the fact that clothing can be removed, that bracket fans will increase air motion, that the men are acclimated to tropical weather, and that a fairly high dry-bulb temperature will prevent "cold shock."

In the Navy, air conditions conducive to comfort frequently do not prevail. Our problem often is to determine *what air environment can be tolerated.*

The upper limits of endurable air conditions may be fixed by various considerations.

(1) An effective temperature of about 86° F. is the upper limit at which heat balance can be maintained at rest without a rise in body temperature.

(2) An effective temperature of 91° F. is an upper limit in compartments deprived of spot-cooling, for

FIGURE 2.—Effective temperature chart showing normal scale of effective temperature. Applicable to inhabitants of the United States under following conditions: A. Clothing: Customary indoor clothing. B. Activity: Sedentary or light muscular work. C. Heating methods: Convection type, i. e., warm air, direct steam or hot water radiators, plenum systems.

men exposed during a 4-hour watch. A rise in body temperature and an increase in pulse rate will occur, even during the resting state. An average rise in body temperature of 0.5° F., and an individual rise of 1.5° F. may be arbitrarily assigned as values limiting further exposure. The corresponding limiting pulse-rate value is 140, a purely arbitrary figure but one that has proved to be useful in the prevention of collapse due to heat.

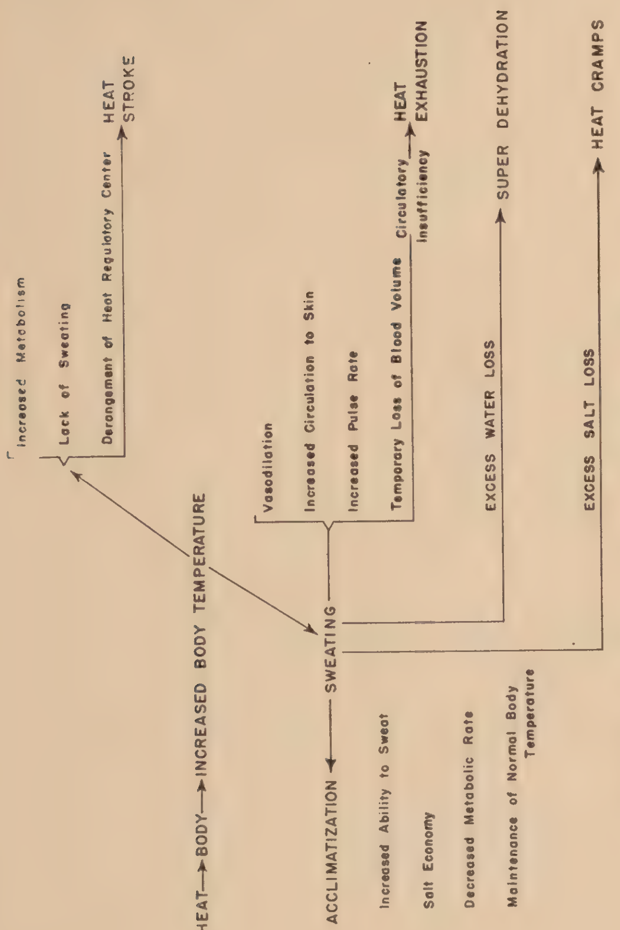
(3) As a result of long experience in mining operations in South Africa, it is considered that 93° F. in air saturated with moisture, hence 93 effective temperature, is a critical level above which many cases of heat prostration occur.

Some tests indicate that the body temperature will reach 100.5° F. in 2 hours at 93 effective temperature, in 1 hour at 95 effective temperature, and in ½ hour at 99 effective temperature.

INFLUENCE OF ADVERSE AIR CONDITIONS.

Effect of heat.—The heat-regulating mechanism fails if the external temperature is so abnormally high that body heat cannot be eliminated as fast as it is produced. Part of it is retained in the body, causing a rise in skin and deep tissue temperature, an increase in the heart rate, and accelerated respiration. The metabolic rate increases also owing to the excessive rise in body temperature, and in extreme conditions a vicious cycle may result which eventually leads to serious physiologic damage. Example: Heat stroke.

Acute overheating leads to four syndromes: *Heat stroke*, *heat exhaustion*, *superdehydration*, and *heat cramps*, figure 3.



SCHEMA OF SYNDROMES INDUCED BY EXCESS HEAT

FIGURE 3.

Heat stroke is usually preceded by cessation of sweating. There is fever and delirium, with full bounding pulse and elevated blood pressure, while the skin is flushed and dry. Immediately important in therapy is rapid heat removal by the best means at hand.

Heat exhaustion or circulatory insufficiency, on the other hand, is characterized by subnormal body temperature, cold, pale, clammy skin, low blood pressure and a state of circulatory shock. Here immediate treatment should be directed toward raising the body temperature to normal, improving the tone of the vascular system and allaying hyperactivity in the digestive musculature.

Of great importance is the physiologic consideration of the shift in blood from the internal organs to the periphery. The dilatation of the blood vessels of the skin and the abnormal distribution of blood to the skin area, merely for the purpose of cooling the body, place a heavy load on the cardiovascular system. This shift in blood, moreover, may explain the prevalence of gastro-intestinal disorders in hot weather.

A practical precept is that individuals in hot environments must be allowed to sit down periodically to relieve the excessive cardiovascular strain. Otherwise the common complaint and the factor that limits endurance is tired, swollen feet.

We are faced by a lack of knowledge as to why one individual develops the dynamic hyperpyrexia response and another the hypothermic shock reaction. *Unfortunately, one experience with either type of excessive heat reaction predisposes the patient to subsequent at-*

tacks and to troublesome prodromal symptoms with exposure to external heat of relatively low order.

Superdehydration is an excessive loss of water as sweat without adequate replacement. The essential phenomena are thirst, reduced salivation, oliguria, acidemia, dyspnea, exhaustion, subnormal temperature, concentration of blood, shriveled skin, and sunken eyes.

Heat cramps in the skeletal muscles bear little relation either to heat stroke or heat exhaustion. The cramps are due primarily to excessive salt loss during profuse and prolonged perspiration without adequate salt intake. Relief is readily obtained by adding ordinary table salt to the drinking water, or taking it in any other convenient form. Sometimes a patient suffering from heat exhaustion will also be suffering from skeletal muscle cramps, but usually the conditions are not associated. Laborers in desert heat and in boiler or furnace rooms are particularly prone to heat cramps because of their excessive perspiration and rapid salt loss.

Salt, salt solutions, fluids, and vitamin C requirements.—Salt loss through the skin as a result of sweating is of the order of 0.1 to 0.5 percent depending upon the degree of acclimatization. During the period of 24 hours, 4 to 8 quarts of fluid and 4 to 8 grams of salt, equivalent to 1 to 2 teaspoons of salt may be lost in this manner.

Replenishment of this quantity of salt is best obtained, not through the ingestion of salt tablets, but by greater ingestion of salt at mealtime or by *adding salt to the drinking water to make a solution of not more than 0.15 percent salt.* The salinity of this solu-

tion is less than that of milk and in cold water it cannot be detected.

If small quantities of salt are not added to the drinking water, the serving of soup or tomato juice will take care of the problem, which is essentially the replacement of salt lost through the skin.

A bouillon cube containing 2 grams of salt, dissolved in a pint of water, twice daily, will usually meet the additional salt requirements.

Present studies have indicated that vitamin C is also excreted in sweat and the addition of vitamin C to the diet is accordingly desirable. Mills has stated further that additional vitamin B_1, thiamine hydrochloride, is beneficial in hot atmospheres.

AIR COOLING—NAVAL CONSIDERATIONS.

Air cooling in living spaces sufficient to prevent men from sweating while at rest is a prime requirement. No single factor, with the exception of food, can be of more value in the maintenance of efficiency. Cooled air ensures the necessary rest for recuperation from strenuous daily activity, and makes for the diurnal change in atmosphere that is so conducive to efficiency and well being in temperate climates.

The experiences, in terms of continued efficiency and well being, at Boulder Dam, in the Tropics, and even in Washington, D. C., in the summer, are proof of the value of an atmosphere cooled sufficiently to prevent sweating of personnel in the resting state.

Overcooling of the air, on the other hand, should be avoided. The principle that must govern naval air-conditioning is provision for the least amount of cooling required to prevent sweating. Usually not more than

10° F. difference in dry-bulb temperature should exist between the cooled and the untreated air.

If this is accomplished, men who may be sweating while at work will not be chilled when they are resting in the conditioned environment. Moreover, men leaving the conditioned compartment will be less likely to develop an idiosyncrasy to heat when they are again subjected to the usual tropical air conditions.

Spot cooling is used in certain very hot spaces, such as engine rooms where it is impossible to provide sufficient outside air to maintain satisfactory temperatures throughout the spaces. Furthermore, too much air change in compartments containing steam propulsion equipment merely serves to cool down the equipment and thus waste heat and fuel, without appreciable improvement of the habitability. For such spaces "spot cooling" is provided. Near each watchstander's station a high velocity blast of outside air is introduced. Due to the high velocity, the incoming air does not at once diffuse and mix with the ambient air, so a "spot" of cooler air occurs in front of the blast terminal, into which the watchstander can occasionally step. This system is effective even at high outside temperatures so long as the spot temperature is considerably lower than the ambient temperature.

Effects of cold.—In the naval service we are concerned not only with the effects of cold air at both normal and abnormal pressures, but also with reactions following exposure in cold water.

In cold regions ashore men may be exposed to temperatures as low as −60° F. In aviation a 2° F. drop in temperature for every thousand feet up to altitudes of

30,000 feet gives rise to ambient temperatures between $-50°$ and $-60°$ F.

The effect of environmental temperature is intimately related to the character of the ambient medium. In diving operations, for example, conducted in cold water at a temperature of 40° F., body heat may be rapidly lost in the compressed atmosphere; on the other hand in rarefied still air at high altitude, temperature $-20°$ F., aviators may not be too uncomfortable if they are protected from the effect of *radiant cooling*.

The general physiologic responses to cold are related to a fall in body temperature which may drop from the normal range of 97.3° to 99.1° F., to values of 92° F. in carbon monoxide poisoning and submersion, to 82° F. during cold treatments, and to values as low as 75° F. in severe alcoholism.

The initial responses to cold are indicative of stimulation of the sympathetic nervous system to produce shivering and a secretion of adrenin, which gives rise to constriction of blood vessels, increased heart rate and blood pressure, hyperglycemia, and increase in metabolism. There is also evidence that the thyroid gland enlarges in response to stimulation by cold. These reactions tend to be beneficial to the healthy individual but harmful to the unfit.

The harmful effects of chilling are manifest in individuals hypersensitive to cold, and in persons susceptible to respiratory infections. Some individuals, for example, exposed to cold water or air may exhibit urticaria and syncope, symptoms indicative of the liberation of abnormal amounts of histamine in the skin.

There is good evidence showing that exposure to cold and to changes in temperature lowers the resistance of animals to infection, apparently by depressing their defensive mechanism. The prevalence of respiratory diseases in cold weather is attributed partly to the lowered resistance of the mucous membranes of the nose and throat which results from the vasomotor shifts of blood in the internal organs.

The local effects of cold are first exhibited by a painful vasoconstriction and cyanosis followed by a reactive hyperemia, normal color, and cessation of pain.

The feet representing a dependent part of the body and possessing the poorest circulation, usually show the complications resulting from exposure to extreme cold and designated by such terms as "trench foot" and "immersion foot."

In commenting on numerous cases of trench foot that occurred during the last war, Lake observed that death occurred in embryo hearts immersed in Ringer's solution at a temperature 21° F. or lower. Further experiments on the rabbit's ear and the human skin indicated that 21° F. was a critical temperature with reference to solidification and permanent damage to tissue.

In true frostbite, therefore, Lake believes that the tissues have reached a temperature of about 21° F. If this happens to the skin of the feet, as was the case with men standing in trenches with wet feet, then actual destruction of skin takes place which may lead to gangrene.

In the case of chilling without actual frostbite, for example, killing of tissues, the parts involved often become edematous on being warmed up. There can be

no doubt that the easiest way to produce the edema of chilling consists in alternating cold and heat quite rapidly. *Therefore, heat should not be applied to an area of the body affected by cold.*

Protection against cold.—Since the normal range of body temperature is less than 2° F., and since acclimatization to cold does not permit an average lowering of effective temperature of more than 6°, it follows that the body must be protected by adequate clothing in cold environment, or the environment itself must be modified.

The tendency has been to overemphasize the second procedure to the neglect of the first.

Thus, heating of the air has often been excessive, producing a dry, hot atmosphere conducive to debilitation and to injury of the membranous nasopharynx, especially when subsequent exposure takes place in cold air.

Emphasis must be placed, therefore, upon the protective value of clothing which serves to insulate the individual from cold. Electrically heated garments provide additional heat, if it is required. It is of interest that pioneer tests of electrically-heated clothing were undertaken at the Experimental Diving Unit, Navy Yard, Washington, D. C., in preparation for cold-water diving.

Not only is it possible to insulate the individual from cold in order to minimize body heat loss, but compartment bulkheads can be insulated to reduce the effect of *radiant cooling* and rapid heat-transfer *through metal conductors.* An example of the value of bulkhead insulation is found in submarine compartments.

In aviation, especially, the insulation of the cabin

interior is of great value when flights occur in air at a temperature of $-56°$ F. The sealing of cabins, moreover, serves to eliminate loss of heat by convection. Thus the rarefied, *still air* acts as an insulator against rapid heat loss from the body.

IN CONCLUSION, IT IS EMPHASIZED THAT OVERHEATING OF AIR IS TO BE AVOIDED IN WINTER, OVERCOOLING OF AIR MUST NOT BE PERMITTED IN SUMMER.

Vitiation of Air.

(*a*) *Oxygen deficiency in closed spaces.*—In unventilated spaces such as sealed compartments, and at high altitudes, oxygen deficiency and carbon dioxide excess are of major significance.

An incident, dramatic in its suddenness, occurred on the battleship *New York* 10 years ago. An officer and three men entered an upper blister compartment which had been closed for several months. The officer who was leading, started down the ladder to the lower compartment and suddenly fell to the bottom in collapse. Three men immediately descended to his assistance and were also overcome. Five additional unprotected persons attempted to reach the victims and were prostrated —nine in all. The officer and one man were dead when finally removed by a rescue group.

Another disaster was reported by the Cavite Navy Yard in the Philippines in 1931. Three civilian workmen entered a freshly painted submarine pontoon. All three were fatally overcome and three additional persons going to their assistance were removed in a state of collapse, but recovered. All of these cases were due to a lack of oxygen in the compartment.

Precautionary measures to be taken are:

(1) Thorough ventilation of all spaces prior to entering.

(2) *The adjustment of a life line to a person entering.*

(3) Immediate availability of oxygen apparatus.

The fatal error repeatedly manifests itself of entering unoccupied compartments without taking the second and third simple, precautionary measures.

(*b*) *Carbon dioxide accumulation* is discussed under submarine ventilation.

(*c*) *Carbon monoxide and other toxic gases and vapors.*—In various industrial establishments and wherever internal-combustion engines, including automobile engines, gas heaters, or other heaters, operate under conditions of imperfect combustion, carbon monoxide is a serious menace; and in industry benzol and many other toxic fumes and gases may present grave problems.

A fundamental principle underlying the physiologic action of gases is illustrated by the time of exposure versus concentration rule for carbon monoxide.

Time of exposure v. *Concentration Rule:*

(1) Time of exposure in hours multiplied by the concentration in parts per 10,000 equals 3 (no perceptible effect).

(2) Time of exposure in hours multiplied by the concentration in parts per 10,000 equals 6 (just perceptible effect).

(3) Time of exposure in hours multiplied by the concentration in parts per 10,000 equals 9 (headache and nausea).

(4) Time of exposure in hours multiplied by the concentration in parts per 10,000 equals 15 (dangerous to life).

In the Hudson River tunnels, for example, a concentration of 4 parts of carbon monoxide per 10,000 is permissible for a truck passing through in 45 minutes. This means 4 multiplied by 0.75 or 3, a concentration devoid of annoyance to the driver.

Symptoms in Relation to Concentration of Carbon Monoxide:

Concentration	*Effect*
0.01 percent or 1 part in 10,000	No symptoms for 2 hours.
0.04 percent or 4 parts in 10,000	No symptoms for 1 hour.
0.06 to 0.07 percent or 6 to 7 parts in 10,000.	Headache and unpleasant symptoms in 1 hour.
0.10 to 0.12 percent or 10 to 12 parts in 10,000.	Dangerous after 1 hour.
0.35 percent or 35 parts in 10,000	Fatal in less than 1 hour.

(*d*) *Bacteria.*—The next type of foreign impurity which must be considered in connection with the atmosphere is the presence of living micro-organisms, particularly those of a pathogenic nature. Wells demonstrated the important fact that while droplets of a certain size (over 0.1–0.2 mm. in diameter) settle rapidly to the floor, those below this critical value lose their water by evaporation before falling any considerable distance. He showed that bacteria from this source may actually persist in the atmosphere in considerable numbers for many hours. These results certainly indicate the possibility of air-borne infection, and recent accomplishments in the sterilization of the air in hospitals or sickrooms by ultraviolet radiation merit further study.

(*e*) *Odors.*—So far as the air of an ordinary occupied space is concerned, there remains one other factor to be considered, that of the unidentified substances associated with the odors produced by human bodies and by various organic substances. There is reasonably clear evidence of an influence of such odors upon appetite which is of real hygienic significance. This was demonstrated by the study of the New York Commission on Ventilation with respect to body odors.

Recently, Herrington and Winslow have shown that relatively slight odors of heated house dust (even when not consciously perceived by the subjects) had a very definite effect in reducing the appetite for food, an influence of distinct hygienic significance.

Yaglou has pointed out the value of using odor as an index of air quality. He found that the odor index as employed by trained observers was a better criterion of air supply per person in a space than the carbon dioxide concentration.

The practical application of this fact is of the greatest importance in the Navy. Thus, the adequacy of ventilation of any occupied compartment, particularly a berthing space, can be determined quickly by trained observers entering the space from another space having a much lower odor level.

Method of conducting studies aboard ship.—It is possible to employ small groups of naval personnel, comprising 8 or 10 men, for the purpose of making systematic observations which serve to define the climatic environment as accurately as do the psychrometric instruments. The men essentially become "comfort" meters to record certain simple but basic physiologic data.

Oral temperature is observed by placing the thermometer under the tongue for a period of 5 minutes and reading in place. Smoking, fluids, and food are prohibited for a period of 1 hour prior to the reading.

Envelope temperature is the temperature of the air layer between the skin and the undershirt at the level of the xyphoid process. It is a convenient index of skin temperature and usually is in close agreement with skin temperature for the corresponding area, as indicated

by the following data applicable to engine-room workers in tropical waters.

Date	*Skin temperature*	*Envelope temperature*
May 16	96.3 F.	96.6 F.
May 17	96.1	95.3
May 18	97.2	97.2
May 19	96.6	96.7

In practice, an 8-inch thermometer graduated to 0.2° F. is suspended from the neck so that the bulb rests over the xyphoid process of the manubrium. The bulb is shielded from clothing and skin by means of perforated x-ray film or plaster of paris. The distance of the bulb from the skin is maintained constant (fig. 4).

The foot-shoe temperature is obtained by placing a thermometer in the shoe so that the bulb rests under the instep (fig. 5).

The feet, representing a part of the body with less adequate circulation by reason of distance from the heart, and because of the retarding influence of gravity, should closely reflect ambient temperature changes.

TABLE 1.—*Data collected on a watchstander in a hot space*

Date and hour	Oral temperature	Envelope temperature	Foot-shoe temperature	Pulse rate	Effective temperature (station)
May 29:					
1	99.3	98.5	101.0	144	[1] 95.5
2	99.2	96.8	101.0	140	
3	98.6	95.5	101.2	108	
4	98.6	96.0	101.2	116	

[1] Collapse would have occurred in such environmental temperature without access to "spot-cooling."

It appears that this temperature is affected not only by the temperature of the foot reflecting, as it does,

peripheral blood flow, but also by the temperature of the shoe itself which in turn is affected by the temperature of the ambient air and the deck on which the men stand.

Foot-shoe temperatures between 70° and 90° F. are consistent with comfort. Below 60° F. the feet are

FIGURE 4.—Envelope temperature.

cold and above 100° F. the feet are hot. Regardless of the air environment the foot-shoe temperature may be regarded as an index of comfort.

The pulse rate is the most easily determined and perhaps the most significant of all physiological observa-

tions. As previously emphasized, an increase in pulse rate usually shows a linear relationship to body temperature. As an indication of the effect of air conditions, it has proved to be extremely valuable.

In an environment compatible with efficient performance, the pulse rate in individuals seated at rest falls

FIGURE 5.—Foot-shoe temperature.

over a period of several hours. In an adverse environment, the pulse rate either fails to decrease or it rises. The pulse rate level, moreover, is of considerable importance.

In trained subjects the increased pulse rate recorded under controlled conditions reflects increased peripheral blood flow essential for body cooling and for the maintenance of the ability to sweat.

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The constancy of the average pulse rate recorded on submarine personnel is shown by the values in table No. 2. The range of average values recorded three times a day for a period of 10 days lay between 79 and 85. A rise in average pulse rate to 90 occurred during a break-down of the cooling system.

TABLE 2.—*Variation in body temperatures and pulse rate*

[Daily observations on 3 groups each consisting of 17 men on a submarine]

Date	Hour	Oral temperature	Envelope temperature	Foot temperature	Pulse rate
		°F.	°F.	°F.	
New England data:					
Aug. 21	1900	98.6	89.9	82	85
Aug. 22	1000	98.3	90.8	87.7	78
	1300	98.4	89.9	90	84
	1700	97.8	87.4	87.2	77
Average		98.2	89.4	88.3	80
Aug. 23	1030	98.4	86.8	84.6	78
Key West data:					
Sept. 11	1000	98.6	91.9	95.3	82
	1300	98.6	91.3	94.2	84
	1700	98.6	92.9	94.5	80
Average		98.6	92	94.7	82
Sept. 12	1000	98.6	90.2	94.2	84
	1300	98.8	92.2	94.7	83
	1700	98.8	93.8	95.5	86
Average		98.7	92.1	94.8	84
Sept. 13	1000	98.6	91.6	96.1	81
	1300	98.7	92.7	96.3	83
	1700	98.6	93.1	95.9	83
Average		98.6	92.5	96.1	82
Sept. 14	1000	98.6	92.8	96.1	82
	1300	98.6	92.8	96.1	82
	1700	98.8	93.1	95.5	83
Average		98.7	92.9	95.9	82
Sept. 15	1000	98.5	92.3	95.8	81
	1300	98.7	92	96.2	83
	1700	98.8	93.1	95.9	82
Average		98.7	92.5	96.0	82
Sept. 16	1000	98.6	92.2	96.3	85
	1300	98.8	91.9	95.8	85
	1700	98.7	92.9	95.7	83
Average		98.7	92.3	95.9	84

TABLE 2.—*Variation in body temperatures and pulse rate*—Con.

Date	Hour	Oral temperature	Envelope temperature	Foot temperature	Pulse rate
Key West data—Con.		°F.	°F.	°F.	
Sept. 17	1000	98.5	93.3	96	82
	1300	98.7	92.5	96.1	83
	1700	98.6	93.5	95.1	78
Average		98.7	93.1	95.7	81
Sept. 18	1000	98.5	92.6	95.8	79
	1300	98.5	92.6	96.1	83
	1700	98.9	92.8	95.7	83
Average		98.6	92.7	95.9	82
Sept. 19	1000	98.5	93	96.1	82
	1300	98.7	92.4	96.7	85
	1700	98.6	92.8	95.8	81
Average		98.6	92.7	96.2	83
Sept. 20	1000	98.5	93.1	96.8	80
	1300	98.8	93.6	97.1	90
Average		98.7	93.4	97.0	85

As an upper limit for pulse rate of men engaged in light activity in hot environments, an arbitrary value of 140 has been used. This limit permits a safety factor, since an increase in pulse rate to 170 or 180 frequently precedes collapse.

Weight and urine output should be determined by weighing the subject and collecting the urine in a measuring flask.

Condition of the skin should be recorded as dry, clammy, damp, wet, and running or dripping.

The mental state should be described as asleep, drowsy, awake, and alert.

Subjective response as to temperature is recorded on a fixed sensation scale, using the following terms: Cold, comfortably cool, comfortable, comfortably warm, and hot.

TABLE 3. *Average values 10 men observed daily in a compartment of a warship*

Date and hour	Schneider index	Pulse rate sitting	Temperature: Oral	Temperature: Envelope	Air temperature: Dry bulb	Air temperature: Wet bulb	Air temperature: Effective temperature	Remarks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
June 3:			°F.	°F.	°F.	°F.	°F.	
1	10.7	70	98.9	88.6	78.5	69	74.5	Comfortably cool; Lima, Peru.
2	10.6	70	98.8	89.9	------	------	------	
3	11.4	67	98.8	89.7	------	------	------	
June 4:								
1	8.8	75	99.1	91.9	83	73	78	Comfortable or comfortably warm; awake. Sea temperature 68.
2	8.6	74	99.1	92.5	------	------	------	
3	9.5	71	98.9	92.2	------	------	------	
4	9.9	68	98.9	92.1	------	------	------	
June 5:								
1	7.6	77	99.4	91.7	83	73	78	5 men comfortable and awake; 3 men comfortable and alert; 2 men comfortably warm. Sea temperature 70.
2	8.6	72	99.1	91.6	------	------	------	
3	9.5	69	98.9	92.1	------	------	------	
4	9.9	66	98.8	91.3	------	------	------	
June 6:								
1	8.1	74	99.2	------	87	80	83	Out of Humboldt current; 6 men comfortably warm, foreheads damp; 4 men too warm, sweating. Sea temperature 83.
2	8.2	72	99.0	------	------	------	------	
3	9.2	69	98.9	------	------	------	------	
4	9.5	68	98.8	92.6	------	------	------	
June 7:								
1	5.7	76	99.1	------	91	81	85	3 men hot, sweating; 4 men too warm; 2 comfortably warm.
2	6.1	74	99.1	------	------	------	------	
3	6.9	71	99.0	------	------	------	------	
4	8.1	68	99.1	93.6				
June 8:								
1	7.2	76	99.2	------	89	80.5	84	8 men comfortably warm; 2 men hot.
2	7.6	73	99.1	------	------	------	------	
3	8.8	69	99.0	------	------	------	------	
4	8.5	69	99.0	93.6	------	------	------	
June 9:								
1	5.7	77	99.3	93.7	91	81	85	4 men hot, sweating; 3 men too warm; 2 men comfortably warm. Sea temperature 83.
2	6.4	75	99.1	------	------	------	------	
3	6.4	73	99.0	------	------	------	------	
4	7.2	70	99.0	------	------	------	------	
June 10:								
1	8.7	73	98.9	93.1	87	76	81	Air conditioned. Sea temperature 68–70. Men comfortable or comfortably cool.
2	9.3	71	98.9	91.8	84.5	70	77	
3	9.6	67	98.8	92.0	84.5	68	76.5	
4	11.0	65	98.8	91.6	83.0	65.5	75	
June 11:								
1	10.4	69	98.9	90.2	80	68	74.5	Sea temperature 62–63. Men comfortably cool. Long Beach, Calif.
2	11.2	67	98.6	90.6	------	------	------	
3	12.4	63	98.5	90.4	------	------	------	
4	11.9	60	98.4	89.1				

VENTILATION OF SUBMARINES

"The ventilation system on a submarine by nature of its construction merits a special consideration. It has three primary functions. It must maintain acceptable conditions of habitability so that the crew can function properly at all times, it must provide sufficient air for the engines when they are operating and it must meet the requirements for battery ventilation under the various conditions of battery operation.

"1. Some of the items of this character are listed:

"(*a*) The necessity for watertight compartmentation.

"(*b*) Carbon dioxide accumulation and oxygen depletion while submerged.

"(*c*) The possibility of accumulation of hydrogen to a dangerous concentration both on the surface and submerged.

"(*d*) The possibility of the presence of toxic gases from the engines or batteries, or from other sources either during normal operations or as the result of a casualty to the vessel.

"(*e*) The possibility of a necessity to abandon ship while submerged.

"The ventilation systems of submarines are designed to provide efficient and adequate ventilation on the surface regardless of whether the engines are running or stopped, whether any hatches are open or closed, whether the vessel is cruising or lying to, whether the battery ventilation is exhausting inboard or outboard, or whether bulkhead doors are open or closed, and submerged with ventilation inboard and bulkhead doors either open or closed.

"A submarine ventilation system thus becomes a compromise between the various factors involved and cannot be expected to operate to the best advantage at all times. The entire personnel of the service whose duties require their consideration of the questions of design, maintenance and operation of the ventilation of submarines should give all these factors most careful study so that the principle and practice of submarine ventilation will be constantly improved.

"On the typical submarine, engine air is supplied through the main engine air-induction valve located in the conning tower fairwater and through outboard piping to the engine room via hull valves. The engines take their air from the engine room. The ship's ventilation supply air enters through the hull ventilation induction valve, also located in the conning tower fairwater, through outboard piping and a hull valve to the hull supply fan.

"Ventilation distribution within the vessel is achieved by means of a supply main duct and an exhaust main duct within the vessel, each running the entire length of the ship and each provided with branches in each compartment. The hull ventilation fans are located in one of the compartments near the longitudinal center of the vessel. The exhaust is so arranged that it can be discharged to the engine room or engine air induction pipe when the engines are running, and can be discharged overboard via the engine air induction piping when the engines are stopped. All vessels are provided with some kind of a cross connection between the exhaust fan discharge and the supply fan intake, so that the fans may be used for recirculation of the ship's air while submerged." (Bureau of Ships Manual.)

The ventilation of submarines becomes a problem especially during submerged cruising when air is recirculated. As aboard surface ships, the important factors for consideration are the physical elements of temperature, humidity, and air movement, and, during prolonged submergence, the carbon dioxide and oxygen content of the air (see also ch. XVII on Submarine Medicine).

The changes in the chemical components of recirculated air are the accumulation of carbon dioxide given off by the body, and the decrease in oxygen content as a result of body utilization.

A man under average conditions in a submarine while submerged consumes about 0.9 cubic foot of oxygen and gives off about 0.75 cubic foot of carbon dioxide per hour.

The instructions for purification of the air are based upon the following factors:

1. (*a*) A concentration of carbon dioxide of one percent or less can be breathed for an indefinite time without any ill effects.

(*b*) A concentration of carbon dioxide of 2 percent will not ordinarily be noticed, but will cause some discomfort if work requiring strenuous exertion is attempted.

(*c*) A concentration of carbon dioxide of 3 percent causes discomfort in breathing even at rest if breathed more than a short time. The concentration should never be allowed to exceed 3 percent and should be reduced as rapidly as possible if it reaches that concentration. The length of time necessary for the concentration of carbon dioxide to reach three percent may be calculated by the following formula:

$$X = \frac{C(3-G)}{75N}$$

where X is the time in hours after diving in which carbon-dioxide concentration will reach 3 percent,

G is the percent concentration of carbon dioxide in atmosphere at time of dive,

C is the net air space of the vessel in cubic feet,

N is the number of men on board.

With reference to oxygen it is desirable to maintain the percentage as closely as possible to the normal level of 20.94. These requirements can be fulfilled in submerged cruising by the early recirculation of air through carbon dioxide absorbent and by oxygen replacement from storage cylinders.

Usually air can be recirculated in submarines for about 15 hours before limiting concentrations of oxygen and carbon dioxide are present. The percentage of carbon dioxide can be easily determined by the colorimetric method. In the absence of oxygen and carbon dioxide analyses, the increased depth and rate of breathing indicates the presence of limiting carbon dioxide concentration, while the failure of a candle to remain lighted denotes a deficiency of oxygen.

The statements of Lieutenant Naquin, USN, commanding officer of the disabled U. S. S. *Squalus*, illustrate some of the problems encountered in an enclosed submarine space.

Every effort was made to conserve the energy of the men, who spent a great deal of time sleeping. The men were instructed to remain calm, as excitement would increase oxygen consumption and carbon dioxide output. One tank of oxygen was used in the control room, which contained about half of the survivors, and another tank in the torpedo room. The intermediate battery compartment was not inhabited, since it was feared that chlorine gas might be generated as a result of entrance of sea water into storage batteries. After a number of hours the odor of chlorine was detected in this compartment, and the men wore "lung" appliances converted into chlorine protectors en route from the

control room to the torpedo room, where escape into the diving bell was effected. Carbon dioxide absorption was facilitated by spreading absorbent throughout the compartments. A noticeable improvement in respirability followed each fresh addition. Except for the men engaged in communication with surface vessels by tapping signals, there was no activity on the part of any of the survivors, who remained in the same positions throughout the period of 28 to 40 hours prior to rescue.

The atmosphere in the submarine was dark, cold, and moist. The men suffered acutely from cold, which was only partially relieved by eating.

Of greater importance than changes in the chemical components of air are the physical factors of temperature, humidity, and air movement. It is the accumulation of moisture in the air which early affects comfort and efficiency. The accumulated moisture in the air during submerged cruising comes from storage batteries and from the body in the form of sweat and as moisture from the lungs. When the temperature of the sea water is high, as it is in operations around Panama, men may lose an average of 5 pounds of water during a 10-hour submerged cruise. Without air conditioning the only relief from the increased humidity is to increase air flow through the compartments and within the compartments, provided that the temperature is below 95° F.

The recent installation of air-conditioning equipment is undoubtedly the greatest development affecting the health and comfort of submarine personnel. The recirculation of cool, filtered air lessens fatigue and limits the spread of infection in the upper part of the respiratory tract. Dry air, clothing, and bedding ensure proper relaxation and rest. When this type of equipment is generally installed, many of the physical hazards incident to submarine service will have been eliminated.

Noxious gases in years past have been the cause of great concern. Of these, *chlorine* is most likely to be encountered when, as a result of structural damage, sea water comes in contact with the storage batteries. *Hydrogen* generated during the charging of batteries is detected by highly sensitive apparatus and eliminated by means of an independent and efficient ventilating system. Small quantities of hydrogen arising during battery discharge may occasionally form inflammable or explosive mixtures during submerged cruising. At the present time the enforcement of safety precautions and the use of gas masks should render negligible any casualties from gas incident to the operation of the submarine.

Tobacco smoke constitutes one of our most difficult problems, particularly in sealed spaces in ships and in the submerged submarine where the air is recirculated. For its effects, cf. chapter XVII on Submarine Medicine.

VENTILATION OF AIRCRAFT[1]

The essential problem in aircraft is the protection of the individual against cold. The atmospheric temperature falls about 2° C. for each 1,000 feet of ascent until 35,000 feet has been reached, after which the temperature remains practically constant at −55° C.

In the still, rarefied air, however, a temperature of −55° C. is not associated with the heat loss from the body that would otherwise occur at ground level. The body is insulated from the cold environment in the partial vacuum which tends to prevent heat loss, and a temperature of −55° C. at 35,000 feet, corresponds to a much higher temperature at sea level.

Under these conditions *radiant cooling* from the cabin walls is a factor of great importance. Hence, insulation of the metal walls becomes a most effective measure.

In the open cockpit or one in which there is air movement, convection cooling renders equivalent a temperature of −55° C. at 35,000 feet and at the ground level.

Under these conditions the individual must be protected by heated clothing.

The heating of aircraft is primarily an engineering problem. It should be stressed that the ability of the individual to adapt himself to cold is limited. Protection must therefore be afforded by the insulated, sealed cabin, heated clothing, and heated cabins.

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[1] See also ch. XIX, Hygiene in Aviation.

Chapter III

WATER AND ITS USES ON SHIPBOARD

For our purposes water aboard ship is obtained from two sources, viz., distilled on board, or shore water stored on board. In either case the medical officer's responsibility is to make certain that the supply is at all times potable.

To insure this, frequent analysis must be made from individual tanks, and any containers used for reserve water storage must be inspected and the water changed frequently (once each month). Specimens for chemical and bacteriological examination should be submitted to shore hospitals or laboratories at 3-month intervals, if possible, and, in addition, at an early date following any casualty in the water system such as salting up, or breaks in water lines where contamination has been made possible. It is necessary to be on the alert at all times for these accidents, and to be water-purity conscious, otherwise too much damage is done before the cause is determined.

In a recent case, following a yard overhaul and drydocking, at which time all fresh-water tanks were drained, scrubbed, and painted, routine water samples were submitted to a naval hospital. Reports were not received prior to sailing for maneuvers, and on the second day at sea the medical officer noted the reporting of men for sick call with enteritis, most cases mild in

degree. There were not many cases, but it was noted they came from all departments of the ship, and continued for the second day. In the evening of the second day a message was received from the hospital laboratory showing contamination of one of the three tanks with colon bacilli. The first lieutenant was at once consulted and he promptly discontinued the use of water from the contaminated tank. No new cases of enteritis were admitted following this procedure, and it was felt that a near calamity for a crew of 3,000 men had been averted.

Careful inspection revealed that there was a defective rubber gasket under the manhole plate to the tank, which allowed bilge water to enter the tank from the top, thus contaminating the entire tank. The gasket was removed, the tank drained, scrubbed, and chlorinated. After careful rinsing, the tank was again filled but no water used until samples had again been submitted and found to be free of contamination. In cases of small ships where storage facilities are limited, one would resume the use of such tanks, but if possible this water should be used for boiler feed rather than for drinking purposes. It should always be kept in mind that the ship must carry on, and the medical officer, as in all other departments, must at times devise ingenious methods of solving difficult problems in order not to allow a ship to be crippled or to interrupt its mission.

The appearance of an excessive amount of salt in the drinking water constitutes a danger signal to all hands, and is usually promptly reported to the medical officer. It has been found that in most cases this is not the result of faulty evaporators; the engineers' force is most likely to detect such an accident before it is manifested in the

drinking water. This is due to the engineroom's need for properly distilled feed water, more free from salt than that needed for drinking purposes.

The experienced medical officer on reporting to a ship watches on inspection trips for any connecting water lines where salt water might inadvertently be turned into fresh water lines. It is still a common custom to have salt water piped into the spud-peeling room for the peeling machine, and into the garbage grinding machine or garbage chute. Probably as a result of recent orders forbiding the use of salt water on board for any purposes other than flushing while ships are lying in contaminated harbors, many ships will provide a connecting line from the fresh water supply to the above-mentioned machines and facilities. Here you often find a neat connecting line—one salt water and the other fresh water—to a joint outlet. All goes well until some one unskilled in the opening and closing of valves turns salt water into the line, forgetting to close the valve from the fresh water line, thus allowing the salt water to back up into the ship's drinking water supply. Due to the pressure it may take several days for this condition to manifest itself by taste, during which time contamination of the drinking water is slowly taking place, which may lead to serious results. The remedy is to prevail upon the first lieutenant to allow no such hook-ups and no connections between fresh and salt water lines. Padlocks on valves are not sufficient. Disconnection is the only sure safeguard, and should be insisted upon.

The complaint of any man on the ship that the water tastes bad should not be disregarded. The cause of the complaint should immediately be sought and trouble for

an entire ship's crew may be averted. It should be kept in mind that the engineering department provides the fresh or distilled water, the first lieutenant has charge of storage and distribution, so one's problems can be shared with them.

Shore Water.

The chief points for consideration in using shore water are source, quality, and methods of transporting. When obtained from Government stations or barges, current reports as to quality and purity are usually available and trustworthy. The medical officer will do well to be on hand when connections are made to the ship and observe that lines are intact and have not been allowed to drag through the polluted water of the harbor or other anchorage. It is advisable to look about the area and judge from appearances whether the personnel involved are experienced in such work and realize the importance of clean handling of water. Inexperience and ignorance as to the laws of general cleanliness may prove disastrous at such times. A hose carrying fresh water to a ship should at all times be kept clear of polluted harbor water.

The ship is responsible for the cleanliness of its tanks, the shore establishment is responsible for supplying pure, potable water. To determine what has been obtained, samples should be sent to a laboratory at regular intervals, and at any other time when in doubt.

In wartime one must be prepared to remedy contaminations of water supply without expending the supply on hand. This may be accomplished by chlorination in accordance with instructions incorporated

in the Manual of the Medical Department, paragraph 2610. Reserve storage tanks for battle purposes where practicable should be cut into the water line in such a manner that there will be a continuous flow of water through the tank, thus preventing stagnation. This is feasible on shipboard, and by installing proper valves the flow through the tanks can be cut off at general quarters and an emergency outlet opened, thus providing a fresh emergency supply of water in case of damage to the ship's water lines. Tanks of 80- to 100-gallon capacity may be suspended from the overhead or secured to bulkheads as space warrants, and should be distributed throughout those areas of the ship in which personnel are concentrated at times of action. It has been learned that not only do injured men crave water during action, but all personnel seem to develop an unnatural thirst due to nervous strain and tension. Where tanks cannot be made available, water containers such as water breakers, jugs, thermos containers and milk cans from the galley should be stored. All these require inspection for cleanliness and occasional changing of the water in them, although stale water uncontaminated is acceptable in the absence of a better supply.

Emergency tanks in sickbay and dressing stations should have not less than the equivalent in gallons of the number of personnel on board divided by five.

Water lines are so extensive on a ship that damage from bombs or torpedoes, although minor so far as ship security is concerned, may interrupt the drinking water system, thus making all hands dependent on a reserve storage supply.

Uses of Water on Board Ship.

Fundamentally the uses of water aboard ship correspond to its uses ashore—the difference being that it must be in all cases used more sparingly on board ship. The amount used is determined by the supply and in many cases the medical officer is forced to help to determine just where the reductions can be made without jeopardizing the health of the men and the sanitation of the ship.

1. Drinking water should be the first consideration. In warm climates this requirement may be estimated at 3 quarts per day per man, remembering that men take salt tablets in these climates.

2. Bathing requires whatever amount is available from one gallon up, and though the amount may be small it is best that men have a daily bath in wartime, as action may be expected at any time. Salt water for bathing is not desirable but may be resorted to in real emergencies.

3. Galley and scullery requirements are almost constant, due to the use of dishwashing machines and sterilizing tanks on most ships. It is believed that this may be estimated at from 2 to 5 gallons per day per man depending on the size of the organization, facilities available, and method used for serving food. During action, sandwiches and cold foods are served which reduces the amount of water used for galley purposes.

4. Laundry requirements vary with the methods used. Central laundry facilities are economical in the use of water compared to the results obtained by individual work. However, in wartime it is not always feasible to spare manpower from guns and war-watches

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to operate a central plant, so other means must be devised.

Sickbay laundry is always an item for consideration and must be well provided for up to a real scarcity of water. At such times bed linen and towels must be conserved where possible. The turnover is so heavy on large ships that sheets and pillow cases become items of concern. Paper towels help to conserve hand towels. Pillows may be eliminated in time of stress. Clean sheets are essential.

5. The sickbay is often considered a place where extravagant use of fresh water prevails. This can easily be true, hence "don'ts" for the medical department are listed.

Don't allow the use of water suction for drying test tubes and pipettes in the laboratory.

Don't permit the use of a constant flow of fresh water through x-ray developing tanks. Use ice if necessary.

Don't permit the use of a large stream of water over scrub-up basins. Have small needle shower heads installed on the outlets and make sure the knee-action valves function smoothly. In cases of necessity, one can scrub in a basin and have small amounts of clean rinse water poured over the hands by an assistant.

Don't allow dripping faucets. Report these leaks to the first lieutenant and see that they are repaired promptly.

Save water in these places so that the galley and scullery may continue to use the needed amount to maintain proper sanitary measures in the feeding of the crew.

The use of salt water for scrubbing decks, in the spud-peeling machine, and for washing clothes is safe on ships cruising a hundred miles off shore. This distance may be reduced in areas where large centers

of population do not have to be considered. However, the medical officer must be on the alert at all times when such substitutions are made to avoid such pitfalls as previously mentioned regarding the use of salt water.

Water hours are necessary on many ships, particularly transports, where ships are loaded beyond their capacity for living comfort and conveniences, and it will be found that men may keep clean and live under sanitary conditions even with limited water supply, where proper supervision by division officers is maintained.

Chapter IV

FOOD AND FOOD INSPECTION

In the maintenance and promotion of health, the quantity and quality of food are of the utmost importance. Food is also important in maintaining the morale and the physical and mental efficiency of fighting men on board ship, in the field, and in the barracks. Food may serve as the medium for transmission of pathogenic organisms, and diets deficient in certain substances will lead to the development of deficiency diseases.

The purchasing of food is centralized in the Bureau of Supplies and Accounts, and several field purchasing offices are available for food supplies. All food is purchased under Federal specifications which are prepared by a board composed of representatives of all the Government agencies concerned with food. All food is inspected upon delivery by inspectors of the Department of Agriculture or by the Navy's own trained inspectors and chemists. All provisions furnished the Navy are guaranteed by the contractor to conform to the provisions of the Federal Food and Drug Act of June 25, 1938.

Contracts for meat and meat-food products are executed sufficiently in advance to allow the deliveries to be inspected properly at the time of preparation, and upon final delivery no meats or meat-food products are

accepted that do not bear the special Navy stamp and are not in compliance with Federal specifications.

It is the policy of the Navy to utilize the services of inspectors of the Agricultural Marketing Service, United States Department of Agriculture, whenever possible, in the inspection of fresh fruits and vegetables. When this is not possible, effort is made to obtain the services of other qualified inspectors of the Department of Agriculture. This also applies to inspection of poultry, butter, cheese, eggs, milk, ice cream, bread, rolls, pastry, and miscellaneous groceries.

The problem of rationing the Navy dates back to the beginning of the Navy itself. There is to be found on the statute books, an act dated March 27, 1794, which was apparently the first ration law. This act not only prescribed the allowances of different articles of food, but the particular items which would be issued on each day of the week. It was directed that on Sunday the total issue for the entire day would consist of 1 pound of bread; 1½ pounds of beef; and one-half pound of rice. Throughout the week there was little variation. Salt pork was issued alternately with beef, and peas and beans on days when rice was not issued. Potatoes or turnips were allowed on Tuesdays when they could be procured. Wednesday was a meatless day, and the ration consisted of 1 pound of bread and 2 ounces of butter, or 6 ounces of molasses; 4 ounces of cheese and one-half pound of rice. On Friday, salt fish was authorized. This apparently very meager ration was augmented by:

> And there shall also be allowed one-half pint of distilled spirits per day, or in lieu thereof, one quart of beer per day to each ration.

The ration cost about 25 cents, including the spirits. In September 1862, the rum was discontinued and the men's pay was increased 5 cents a day in lieu of the spirit ration.

The Navy ration has gradually improved until at the present time its nutritional value is maintained at a high standard. A supply of less than enough of any of several specific nutrients constitutes nutritional failure, and such failure leads to malnutrition. The several nutrients required by the human organism are as follows: Oxygen, absorbed by way of the lungs from inspired air; water, obtained as such by drinking aqueous liquids, also obtained from many foods, also to a small extent by oxidation of the hydrogen in fat and other nonaqueous material; calcium, phosphorus, iron and other inorganic elements which commonly are spoken of as minerals; certain complex organic compounds, among which are such amino acids and vitamins as cannot be manufactured in the body.

Amino acids are the building stones of protein. Food proteins vary in the amino acids they contain. In general, proteins from meats, fish, eggs, or milk meet the amino-acid requirements of man better than do the proteins of vegetable origin.

Vitamins are found in all natural or unprocessed foods, but more abundantly in some than in others. Vitamin C (ascorbic acid), for instance, lack of which leads to poor healing of wounds and ultimately to scurvy, is provided liberally by orange, grapefruit, lemon, lime, and tomato; less well by many other fruits and vegetables. It is absent in the grains and low or absent in meats. Vitamin B_1 (thiamine), lack of which results in disorders of the nervous system and ultimately

leads to a polyneuritis, is well provided by grains, meats, peas, and beans, less well by other vegetables, and relatively little if at all by most fruits. Vitamin A, lack of which early affects the eyes and skin, is found in butter and cream; the provitamin carotene, which is converted to vitamin A in the organism, is richly present only in vegetables and fruits of a green or yellow color, such as carrots and apricots. The fish-liver oils alone provide much vitamin D. For this vitamin, lack of which interferes with absorption and utilization of calcium, dependence by adults is usually placed on exposure to the sun.

Two studies have recently been made of the nutritive value of the Navy ration. The first study was made on the basis of the food received by the personnel of a battleship during the calendar year 1940. Average nutritive values for various food groups such as meats, vegetables, cereals, etc., reported in the scientific literature, were used to calculate the nutrients received daily by each man. The second study was made on the basis of the provision requirements for 1,000 men on a 13-week cruise of the United States Pacific Fleet Base Force in 1941. Results of the two studies are shown in the following table in comparison with the recommended daily allowances for a moderately active man as proposed by the Committee on Food and Nutrition of the National Research Council.

TABLE 4

	National Research Council recommendation	Average nutritional factors received daily by enlisted men (battleship study)	Average nutritional factors received daily by enlisted men (base force study)
Calories	3,000	4,118	4,620.
Protein	70 gm	145 gm	130 gm.
Carbohydrate		504 gm	611 gm.
Fat		167 gm	180 gm.
Calcium	0.8 gm	0.92 gm	0.84 gm.
Iron	12 mg	27 mg	32 mg.
Vitamin A	5,000 I. U	16,460 I. U	15,125 I. U.
Vitamin B_1 (thiamine)	2 mg	3.2 mg	2.6 mg.
Vitamin C (ascorbic acid)	75 mg	150 mg	190 mg.
Vitamin B_2 (riboflavin)	3 mg	3.5 mg	2.8 mg.
Nicotinic acid (niacin)	20 mg		
Vitamin D	400 units		
Percent calories as—		*Percent*	*Percent*
Protein (10 to 15 percent for well-balanced diet)		14	12
Carbohydrate (55 to 70 percent for well-balanced diet)		49	53
Fat (20 to 30 percent for well-balanced diet)		36	35

The values shown above for the Navy ration are on the fresh basis and do not take into consideration possible losses during storage, cooking, and canning, but it is considered that the quantities of nutrients supplied should be sufficient to cover losses of that character which might occur. It will be noted that according to present standards, the ration is adequate in all respects.

Recognizing that rations fail at times to provide an adequate supply of vitamins when troops are operating far from the home base, a capsule containing the vitamins of established significance has been made available on the Navy supply table. This capsule is prepared after a formula submitted by the Subcommittee on Medical Nutrition of the Committee on Medicine of the National Research Council. Its formula is such that

each capsule contains a definite fraction approximately one-half of the recommended daily allowances of vitamins for an adult man at moderate activity. Each capsule provides thiamine 1 mg.; riboflavin 1.5 mg.; niacin 10 mg.; ascorbic acid 37.5 mg.; vitamin A 2,500 I. U. and vitamin D 200 or 250 U. S. P. units.

Inspection of Food.

Fresh food not previously passed upon by a United States Government inspection should be inspected by a medical officer, and acceptance or rejection determined at once. Any food found not in accordance with purchase specifications or which may reasonably be considered to menace the health of the personnel should be rejected or recommended for destruction, as the case may be. The ship's medical officer as well as medical officers with troops in the field should regularly inspect the issue rooms, galleys, butcher shops, and bake shops, and make suitable recommendations if any unsatisfactory condition is observed regarding the storage, handling, preparation, and serving of food.

All food handlers—cooks, butchers, bakers, helpers, and messmen should be required to keep their hands as well as utensils and implements used in the preparation and serving of foods, scrupulously clean. Strict supervision should be maintained over the health of food handlers to insure prompt detection of infectious disease.

Medical officers should receive copies of the weekly menus for the general mess and note whether or not a balanced ration is being prepared. The most frequent defect, both on board ship and in the field, is a too high percentage of carbohydrates.

When animals are purchased alive to be slaughtered by or for personnel of the Navy or Marine Corps, as may be required for a naval vessel under certain circumstances or for an expeditionary force in the field, a medical officer should inspect the animals before slaughter and examine the carcasses after slaughter.

Ante-mortem inspection.—This inspection will eliminate animals that are immature, emaciated, feeble, crippled, appearing ill, or exhibiting skin lesions. Females in advanced state of pregnancy should be rejected. Calves should be at least 3 weeks of age before slaughter.

Post-mortem inspection.—It is essential that this inspection be made immediately after slaughter when all parts are intact; carefully inspecting serous membranes, lymph glands, tongue, viscera, glandular organs, and lungs for evidence of disease. When in doubt, it is best to reject those animals exhibiting undetermined pathological changes.

Principal diseases and conditions for which animals should be rejected.

1. Tuberculosis.
2. Pyemia.
3. Foot and mouth disease.
4. Actinomycosis.
5. Pneumonia.
6. Inflammatory conditions of serous membranes.
7. Advanced pregnancy.
8. Recent parturition.
9. Metritis.
10. Pyometria.
11. Emaciation.
12. Abscesses.

13. Scabies.
14. Parasitic infections.
15. Icterus.
16. Melanosis.

Good, high-grade meat is dry, firm to the touch, of normal color, and free from abnormal odors. A wet, slimy, or moldy surface is indicative of beginning surface spoilage. Slime is to be found most frequently on the peritoneal and pleural surfaces or where two surfaces are in apposition. Softened areas usually indicate decomposition.

The color of choice fresh meat should be as follows:

Beef	Bright red
Veal	Pinkish brown
Mutton	Dark pink or red
Lamb	Light pink
Pork	Light pink

Abnormally dark colors are caused by advanced age, overheating or disease at time of slaughter, improper bleeding, or prolonged storage in chill rooms. Sour, putrid, or other abnormal odors are indicative of spoilage.

When decomposition of meat is suspected, the tainted portions shall be trimmed off and a probe sunk into the underlying deep tissues. If decomposition is present, the characteristic odor of putrefaction will surround the probe. A whole quarter of beef should not be condemned because a portion of it has begun to decompose, as it is often possible to trim off the tainted portion and use the remainder.

If meat is to be frozen, it should be placed in a room for 24 hours with a temperature of about 34° F. to com-

pletely eliminate body heat. Meat frozen immediately after slaughter will spoil in the deep portions.

Fresh fruit and vegetables.—When these products have not been previously inspected and do not show the proper stamp, it is important to bear in mind that they are very perishable and the surface appearance is no guarantee of the interior condition. Common defects encountered in fresh fruits are: Cuts, skin cracks, worm holes, softness, skin blemishes, overripeness, and poor form. Vegetables should be free from decay, mold, frost injury, disease, blemishes, and insect or mechanical injury.

Chapter V

LIGHTING OF SHIPS

Proper lighting on board ship contributes definitely to good morale. By it the health and comfort of the entire personnel is improved. There is no question but that good vision is extremely essential and that good lighting is equally as essential to protect good vision. It has been said that 85 percent of all knowledge is gained through the visual sense and at least that much of one's bodily motion is controlled by the eyes. Lighting on board ship is more important today than ever before. Due to present war conditions, it has been found advisable to do away with all portholes, with the result that a great part of the ship's spaces and compartments must be artificially illuminated at all times.

The first question to be settled is: What is good illumination? On a bright, sunny day the level of illumination out-of-doors may be as high as 10,000 foot-candles. We seem to go about in this lighting without trouble; in fact, there is something very pleasant about it. Even on a very dreary day the number of foot-candles runs up to several hundred. Indoors presents a different picture. Spaces in a private home are frequently poorly lighted with foot-candles at best from 2 to 10. On some desks, or around special reading lights, 20 to 50 foot-candles are not unusual, but this amount of lighting is frequently spoken of as being too bright,

however unfounded the criticism. It must be borne in mind that on board ship a great many of the hours of the day are spent below decks and the personnel are required to work under artificial lighting.

One of the most distressing conditions that comes from poor lighting is eye fatigue. There is nothing more disturbing to human efficiency than eye exhaustion. For example, certain researchers show that ocular muscle fatigue, produced by reading, is approximately three times as great after reading for an hour under 1 foot-candle, as it is after an hour's reading of the same printed matter under 100 foot-candles. Very often the personnel coming down into the closed spaces have been on watch for a number of hours and are already fatigued bodily. More discomfort should not be added to their weariness by producing eye fatigue through poor lighting.

Glare.—On the practical side of good lighting is the preventing of accidents on board ship. Lighting must be of proper quality for good seeing. Glare, diffusion, direction, and distribution are all significant factors. Glare can be defined as any brightness within the field of vision of such character as to cause discomfort, annoyance, or interference with vision. It tends to injure the eye and disturbs the nervous system. It causes discomfort and fatigue and thereby reduces the efficiency of the personnel. It interferes with clear vision and again reduces efficiency, and in many cases it increases the risk of accident or injury to the personnel.

There are two common forms of glare: *Direct* and *reflected.*

Direct glare is caused by excessive brightness, or high-brightness—contrast within the visual field, such as

results from unshielded lamps or high-brightness surfaces of fixtures. Direct glare is very common aboard naval vessels. Much of it is caused by bare lamps scattered about passageways and living spaces. These bare lamps are too bright and are a source of constant shock to the eyes. Glare often results when there has been an effort to provide more light by increasing the wattage. Crude means of eliminating glare are very common, e. g., parchment shades over lamps in staterooms, tin and paper cone reflectors over lamps in offices. Metal troughs and shades constructed on the ship are useful but are not uniform and do not always bring about the desired results. The use of improved types of reading lamps, such as those that conform to I. E. S.[1] specifications are to be recommended.

Reflected glare, as the name implies, is caused by reflection from bright surfaces, such as the overhead, desk tops, and any other bright surfaces that may come within the visual field. Highly polished machine parts, smooth finished surfaces, varnished table tops, and other highly reflective surfaces are all too frequent. Reflected glare is usually more annoying than direct glare because it is generally close to the line of vision and the eye cannot avoid it. The answer here should be easy; do away with all highly polished surfaces wherever possible.

Diffusion and distribution of light.—Some directional and shadow effects are desirable in general illumination for accentuating the depth and form of solid objects. Generally only shadows of softer and less pronounced types should be allowed. Alternate light and dark areas in strong contrasts are undesirable, because the eye has difficulty adjusting itself to the two illuminations; under

[1] Illuminating Engineering Society.

such conditions seeing becomes trying. For this reason purely local lighting, restricted to a small work area, is unsatisfactory unless there is sufficient general illumination in the room. This condition is altogether too common on naval vessels.

Structural conditions in compartments sometimes make it impracticable to provide general lighting throughout the entire space. The result is that it is necessary to have supplementary lighting at the particular points of work, either with units attached to the machines, or with units mounted from the overhead but properly located with respect to the machines. Care must be taken to see that the lighting units are not entirely those producing a closely confined beam directed solely at the work. In other words, there should be an even diffusion from the lighting source, giving as nearly as possible a unified distribution of foot-candles over the entire area and surroundings. If this is not done the man at work will have his attention focused on the brightly lighted area and each time he looks up to rest his vision, as he will do normally, his eye must adjust itself to the much darker surroundings. The result is rapid fatigue of the eye muscles. A good rule to follow would be supplementary lighting that will give 50 foot-candles and a general lighting of spaces of 10 foot-candles. At no time should the general illumination be less than 5 foot-candles.

Color of light.—The "white" light is the one in general use in the Navy and should be considered the desirable one. However, the so-called daylight lamps which have blue glass bulbs can be used and may be more agreeable to some people than so-called white light. One must remember, however, that it takes more

wattage to give the same amount of light when the blue bulb is used.

Color of surroundings.—In general light-colored or tinted surfaces are desirable for walls and overhead. They increase the utilization of light because they reflect more light toward the working areas. The overhead, generally speaking, should be painted a flat white. A flat finish is desirable to prevent specular reflection from bright light sources which would otherwise be shielded from view. A white color provides the highest reflection factor. Certain shades of green are desirable for side walls, but it should be remembered that when the darker green is used the foot-candles on the working spaces will be reduced accordingly. Green should never be used for the overhead.

Lighting fixtures.—Lighting fixtures for naval vessels cannot be designed entirely for efficiency, good lighting, and appearance, as is possible ashore. On board ship the factors of weight, size, and strength are all-important, and very often a compromise must be made. In the turrets and handling rooms, because of the tremendous amount of piping, ducts, control cables, etc., there is no way to lay down a fixed rule for any set lighting fixtures. Safety is paramount here, and all fixtures must be designed from a safety standpoint. Even so, there is no excuse for glaring, bare lamps. In such spaces as a sickbay, dispensary, operating room, and dental office a higher level of lighting is considered necessary. There should be good general lighting with available high-intensity spot lights.

Working areas—machinery spaces, shops, laundries, chart houses, offices.—Most machinery spaces can be lighted in a manner very similar to industrial interiors

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ashore, that is, with dome reflectors, with or without steamtight fittings, as the atmospheric conditions of the space may dictate.

In machine shops the lighting fixtures should be arranged with respect to the machines and located so that the men do not stand in their own shadows. Auxiliary lighting equipment should be provided for all such spaces. High illumination should be provided.

In the laundry there is little need for uniform spacing of lighting fixtures. Instead, lights should be placed with careful regard to such machines as ironers, collar machines, sorting tables, etc.

The charthouse is a good example of a space where good lighting must be provided, free from glare. It is here where men work on fine details over long periods. General lighting is desirable with good spot lighting, always remembering that the eyes must be protected from direct illumination and surfaces must be of nonspecular reflecting quality. Indirect lighting would be ideal in the charthouse because of the soft effect and freedom from shadows, but the confined space makes this difficult. A fluorescent fixture gives excellent service if it can be installed, but it is usually too bulky or cumbersome for charthouse use.

Lighting of office spaces on board ship is a difficult problem. Here, too, fluorescent fixtures are very desirable but unless they are used in desk models it seems almost impossible to find room enough to get proper installation. An effort should be made to obtain at least 30 foot-candles for desk spaces.

Galley, pantry, butcher shop, bakery, scullery.—In these spaces there is real need for a liberal amount of illumination, because cleanliness, accurate work, and

good appearance of the products are absolutely essential. A high level of lighting is very desirable in all of these spaces and it should be provided with fixtures that do not give direct or reflected glare.

In the galley adequate light is particularly needed over the ranges, kettles, sinks, and work tables. The health of the crew may be affected seriously if cooks cannot see properly in preparing the food. Lighting fixtures should be cleaned frequently to remove the coating deposit caused by steam and vapors.

The same comment can be made on the pantry, butcher shop, bakery, and scullery insofar as good lighting means cleanliness.

Living spaces—staterooms, wardrooms, C. P. O.'s mess.—The lighting should be such as to promote comfort and at the same time be of adequate quantity for reading and for other visual tasks. Indirect or semi-indirect lighting is greatly to be preferred, but the low overhead makes indirect lighting difficult. Supplementary lights may be provided by the use of well-constructed reading lamps.

Crew spaces.—Here we have a difficult problem in lighting because of the considerable wattage required if adequate seeing conditions are to be made available for all of the men living in these large compartments. It is likewise impracticable to provide individual bunk lighting. Nevertheless the men will read in their bunks, regardless of whether or not the light is sufficient for reading purposes. The most practical solution seems to be to select certain sides, or corners, of the crew's spaces where the men naturally congregate for reading, writing, or card playing, and here lighting should be provided of from 30 to 50 foot-candles. Gen-

eral lighting should be provided in these spaces of not less than 5 foot-candles.

Light sources.—The incandescent lamp has been the standard light source on naval vessels for many years. The lamps designed especially for rough service have a much greater ability to stand shock than the standard lamps used ashore. They are available in from 50- to 200-watt sizes. It should be pointed out, however, that in obtaining greater ruggedness there is some loss in the efficiency of light production.

TABLE 5

	Navy specifications (general lighting)	American recommended practice (minimum on work)
	Foot-candles	*Foot-candles*
Machinery spaces, engines, generators, etc.	5	20.
Switchboards (gages, etc.)		30.
Shops—general, repair, etc.	10	20—rough work. 30—medium work.
Shops—fire control, aviation, radio	20	50—fine work. 100—extra fine work.
Shop—print	10	30 to 100.
Paint mixing	10	10.
Stowage	2	5—bulky. 10—fine.
Bakery	3	20.
Laundry	10	20.
Offices	5	25—general work. 50—long, close work.
Charthouse	5	30.
Passageways	2	5.

From the above table it is apparent that the values of general lighting may be raised by supplemental lighting (detail illumination) to yield the values given in column 2.

The greatest upward step in efficiency of light sources has been the development of the fluorescent lamp. These lamps are quite rugged. The main problem, however, is that of supporting a relatively long glass tube so that there will be minimum breakage. Unfortunately, in the present state these lamps have to be tubular in form and

supplied with alternating current for good efficiency. Fluorescent lamps have another specific advantage in that they efficiently produce light which is roughly comparable to daylight. We all like daylight color, for our eyes have been educated under it. The fluorescent lamp also provides cooler light. Less than half the watts are needed to give the same level of illumination as in the standard light. Furthermore, fluorescent lamps are relatively soft to the eyes, a helpful feature when bare lamps are used. The fluorescent lamp seems to be the answer in a search for better lighting conditions on board ship:

> (1) In the lowering of glare; (2) from the standpoint of getting additional foot-candles without great increase of electrical consumption; (3) in providing better seeing conditions.

The use of fluorescent lamps, however, presents some complications because of the pecularities of construction on board ship. They require a great many more electrical connections than do incandescent lamps. A transformer is generally necessary, and this means additional weight; and often a starting mechanism of some kind to preheat the cathodes in the lamps further places demands upon the ship's space and tonnage.

Common sense must be used at all times when considering lighting in any form. Research is going on constantly, and during the past 2 years much has been done to utilize the red end of the spectrum of light sources. For many years battle lights have been blue. Lighting of gunsights and other instrument panels have been by means of blue lights. It is a well-known fact that a blue light will be seen at a much greater distance

at night than will a light that has its chief rays in the red end of the spectrum. Hence, the red light is recommended for all purposes where it is essential to maintain dark adaptation.

Again we turn to research for better light and better lighting, and in the development of both new and old light sources, more simple and reliable means of lighting will be found.

Chapter VI

NAVAL CLOTHING

Clothing promotes the efficient and comfortable functioning of the human body under varying conditions by (1) protecting it from heat, cold, water, fire, trauma, etc.; (2) by mitigation of climatic factors; and (3) by aiding in the maintenance of dynamic body-heat balance. In effect, clothing acts to establish an immediate environment about the body which is more conducive to its functioning than external conditions.

For practical utilization of clothing, it is essential to appreciate the fundamental problems and relationships between the physiologic, climatic, and engineering elements involved.

Physiology of Body Heat Balance.

Heat is a vital byproduct of the living human body. The body balances heat gain and heat loss by varying heat production and by altering heat loss. The elements involved are graphically outlined in figure 6.

Balance, under warm environmental conditions or when heat must be dissipated from the body, is maintained by an increased blood flow to the surface of the body. This additional body heat may be brought on by work, by exercise at ordinary temperature, or by elevated temperature due to weather conditions and similar factors. The flow of blood to the body surface is

increased, and the sweat glands are stimulated to activity. The activity of the sweat glands raises the mois-

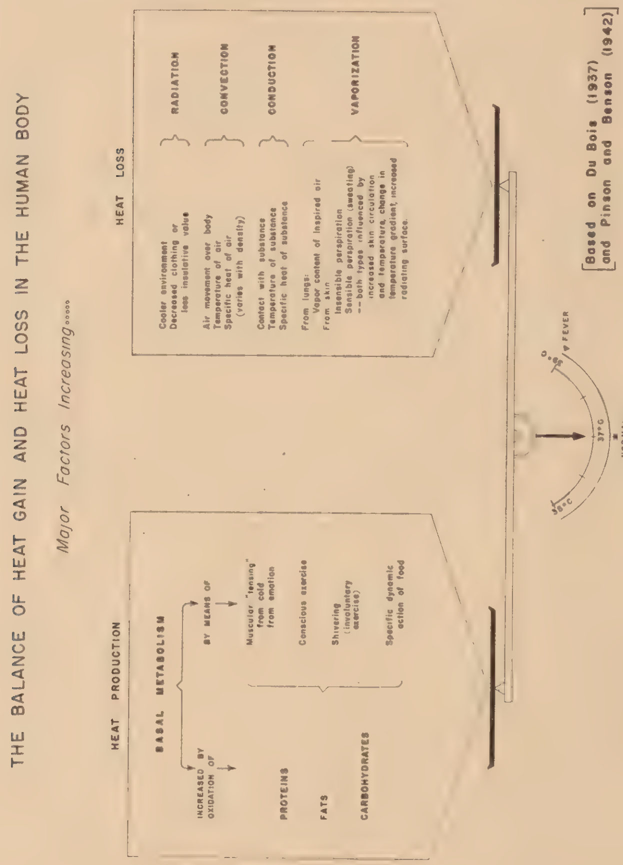

FIGURE 6.

ture content and the heat is lost normally by radiation, convection, vaporization, and conduction.

Perspiration and vaporization must account for most of the body-heat loss under hot conditions, especially where surrounding surfaces possess a higher radiation value or are warmer than the body, and where air movement is at a minimum or the air is warmer than the body. Perspiration can lower the body temperature only when it evaporates from the body. If it evaporates from clothing, it may lower the temperature of the immediately surrounding air. Water of perspiration that runs off the body or is wiped off represents a loss in terms of vaporization. If the environmental air is both hot and saturated with water, all modes of heat loss are restricted, body temperature will rise, and heat stroke result.[1]

Balance under cold environmental conditions is a problem of conservation of heat produced by the body. Sweat secretion ceases. Heat loss by vaporization is restricted to (1) insensible perspiration through the skin, and (2) evaporation due to saturation of inspired air in the lungs.

Heat stored in the tissues of the body protects against sudden changes incurred by external cooling. Storage supplies a specific amount of heat on demand by the atmosphere before the body itself can increase its metabolism to meet increased requirements. However, when 5 or 10 percent of this storage has been removed from the body, pain sensations begin. This is, in effect, the cold warning the body of its heat deficiency. The body, taking cognizance, increases its metabolic rate by shivering.

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[1] For further discussion of the physiological effects of heat, salt, and water loss, and heat stroke see ch. II, "Ventilation and Air Conditioning on Shipboard," especially fig. 3, "Scheme of Syndromes Induced by Excess Heat."

In acclimatization to cold conditions the principal physical adjustment involves blood redistribution. Blood flow to the skin is decreased, thus conserving vital body heat. As a result, the tissues become poorer conductors of heat in a ratio of approximately 1 to 4. This effect is most notable in the extremities. The hands and feet—especially the fingers and toes—are, therefore, the best thermostatic indicators of body temperature conditions. In these areas decreased blood flow serves the essential and quite useful purpose of reducing heat loss and enabling the body as a whole to maintain a heat balance. But in a sense the appendages are sacrificed, for the decreased circulation raises the minimum tolerable environmental temperature which these extremities can withstand without freezing.

As compared with persons acclimatized to cold, the extremities of the unacclimatized body are supplied with greater quantities of heat. Acclimatized persons can stand the pain of cold more readily, can dress with less body clothing, and can therefore move with greater efficiency. Paradoxically, however, they apparently will suffer cold hands and feet more quickly than the unacclimatized person when metabolic heat production drops. On the other hand the unacclimatized person, when exposed to conditions potentially lethal, will perish sooner because the same flow of heat from his body which temporarily is warming his extremities is also sapping vital heat.

Numerous other variables enter into body heat production. Unconscious tensing of muscles and shivering may increase body-heat production substantially, but the process is decidedly unpleasant. Emotional reactions, especially fear, expressly affect the thermal out-

put of the body, and are apparently capable of increasing body-heat output by as much as 200 to 300 calories. Fatigue is an important negative factor. Illness may disrupt the entire body-heat balance mechanism by preventing the relief from fever provided by perspiration. Trauma may specifically affect localized areas of the body, and alter local thermal output. The quantity, quality, digestibility, and caloric content of food are important factors.[2]

THE INFLUENCE OF CLIMATE.

The major external variant affecting the heat production of the body is what is normally termed climate. Although it has been customary to express environmental conditions affecting body heat primarily in terms of temperature, properly humidity, wind velocity, altitude, and varying man-made conditions also should be considered. These conditions may be enumerated as operations on board ship, below the sea, in the air, in fire rooms, in armored vehicles, and the like.

Under hot environmental conditions, excessive humidity inhibits the heat-loss mechanisms of the body. Between 90° and 95° Effective Temperature[3] the limit of human endurance is normally reached, at least for periods of 3 hours or more. Wind velocity and the resulting cooling effect is a factor of considerable importance under both hot and cold conditions: Under the former to be taken advantage of as a means of removing heat from the body; under cold conditions, to insulate the body against its cooling. Variations in

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[2] See ch. IV, "Food and Food Inspection," for further elaboration.

[3] See ch. II, "Ventilating and Air Conditioning on Shipboard," for a discussion of the effective temperature concept.

altitude affect air pressure, availability of oxygen and temperature. For altitude temperature changes see pages 37 and 235.

Thermaldynamic Aspects of Textiles.

Textile fibers in most common use are cotton, wool, and rayon. These differ in suitability for a given purpose depending upon their physical properties such as fineness, strength, elasticity, resilience, moisture content; upon their sensitivity to chemicals such as cleaning compounds; and upon their susceptibility to organisms such as fungi, bacteria, and insects.

The thermal insulation afforded by a fabric is more dependent upon the thickness of the fabric than upon the kind of fiber. Cotton, wool, and rayon, if made into fabrics of the same thickness and of similar constructions, afford relatively the same thermal insulation. Wool, however, is particularly suitable for making thick fabrics of low density. Such fabrics contain large amounts of enmeshed air and accordingly have high resistance to the passage of heat. Thin, open-weave fabrics are cool because they allow the free circulation of air.

Fabrics differ substantially in their ability to absorb or transmit moisture and it is essential, especially under cold conditions, that perspiration, sensible and insensible, be allowed to evaporate. A dry garment, before it comes into hygroscopic equilibrium with the body and atmosphere, will absorb insensible perspiration from the body to the extent of canceling the normal 10 percent heat loss from this source.

In fact garments having a lower relative humidity than the atmosphere will attempt to absorb moisture, thereby increasing their temperature due to heat re-

leased by condensation. This absorption usually occurs within the first or second hour. Thus garments, especially of wool, not only serve as insulators, but as minor heat producers.

Major Types and Problems of Clothing.

Protection from heat.—Free ventilation of the skin is essential to promote cooling by evaporation of perspiration. As a general rule hot-weather garments should be loose, thin, and lightweight. The neck should be open, the sleeves and trouser legs short.

Constriction at the trunk may be avoided by shorts buttoned to the shirt, or by suspenders when a coat is worn. Longitudinal slits under the arms of the shirt and coat promote ventilation and are visible only when the arms are raised. Heavy starched clothing is impervious to air and should be avoided. Underclothing, even for persons with poor perspiration, is much to be desired.

Shorts and shirt, such as officially designated by the Navy for general tropical wear, afford little protection from insects, scratches and abrasions, or flash burns. Standard undress whites, frequently worn without the jumper, also result frequently in serious sunburn. Men on watch, at guns, and on lookout should be thoroughly protected, including sun or other helmet.

Jungle fighting in the Pacific area has clearly demonstrated the necessity of long trousers and sleeves for all types of operations. Apparently as compared to shorts, long trousers of similar material only insignificantly increase body heat.

The color of hot-weather clothing affects substantially the amount of solar radiation that will be ab-

sorbed. White will generally absorb the smallest amount of radiated energy, black twice as much.

The best interests of hygiene in the Tropics are served by clothing that cannot only be readily and repeatedly washed, but that can also be sterilized or disinfected by boiling. Parasitic skin diseases are very prevalent in the Tropics and it is regarded as next to impossible to cure those caused by molds or mites without thorough and repeated disinfection of all clothing in contact with the infected skin.

Care must be taken to protect against sudden or considerable changes in temperature. After prolonged exposure to constant heat, the body becomes extremely sensitive to such changes. A drop of more than 10° F. produces a disagreeable sensation of cold, and unless warmer clothing is put on promptly a further drop may cause chilling and diarrhea.

Acclimatization in advance of arrival of troops shifted from their native climates to tropical areas is of special importance. The United States Naval Medical School suggests the following practical steps:

1. If time is available and the season is suitable, troops destined for service in the Tropics should undertake a month of vigorous work in summer heat, just before sailing.

2. If time is short and the season is unfavorable, equally good results can be secured by having the men do hard work 1½ to 2 hours daily for 3 or 4 weeks in a building with controllable temperature and humidity as follows:

Simulating average tropical climate—Temperature 90° F., humidity 70 percent.

Simulating average desert climate—Temperature 104° F., humidity 25 percent.

Merely having the men work for 1½ to 2 hours daily for 7 days in an artificially heated building will produce good results; or having them march for 7 days at 4 miles

per hour on the level, or 3½ miles per hour on a 5-percent grade, long enough to raise body temperature and pulse rate, and promote free sweating. If such daily exercises are found to be too exhausting, a rest day may be interpolated after the second and fourth days.

3. Since most well-acclimatized men tend to retain their condition for at least 3 weeks after stopping work, it is recommended that men during transit to a tropical combat area be given enough vigorous exercises each day to induce free sweating.

4. Since sweating depends on skin area, and since skin area per unit of bulk is greater in medium and thin individuals, there is theoretical objection to the stocky and large build for tropical work involving great physical stress.

Protection from cold.—Three layers of clothing are normally involved in cold weather protection: (1) The underwear layer, (2) the insulation layer; and (3) the wind and water resistant layer. These are well illustrated by the Navy's winter clothing issues (figs. 7 and 8).

(1) *Underwear* is one of the most important elements of cold weather clothing. It serves as a heat filter to slow down radiation and convection and to conduct moisture away from the body. Underwear should be form-fitting, moderately dense, absorbent, lightweight, soft but with sufficient body to withstand compression. One-piece woolen underwear is preferable since it absorbs a large amount of perspiration, maintains the body in relative dryness, eliminates double insulation at the trunk and makes for more comfortable wearing.

Intense drying of all woolen clothing, especially underwear, socks, etc., increases its efficiency considerably. Frequent changing of garments, and the practice of drying at night the underwear used during the day are especially helpful.

FIGURE 7.—The Navy's special winter clothing is designed to provide protection for personnel assigned to duty in which they are required to undergo continuous exposure to severely cold weather. The illustrated outfit consists of a two-piece woolen underwear suit with full-length sleeves and legs. This is worn under regular clothing and knee-length woolen socks. Outer garments are made of tight-woven, wool-lined jungle-cloth in dark blue. Trousers are of overall type, tieing at the ankles over the arctics. The jacket, fastened by a zipper, has woven wrist, neck, and waist bands. Gloves are one-finger, leather with wool lining. The helmet is jungle-cloth, fleece-lined, with a neck-shield. For extreme weather dark-tinted plastic goggles are supplied as well as a jungle-cloth face mask with an apron which fits beneath the jacket neck. (Outfit from Bureau of Ships; photograph by Bureau of Aeronautics.)

(2) *Insulation* involves usually normal clothing plus special outer wear. Figure 7 illustrates the Navy's present prescribed cold-dry-weather outfit.

Care must be exercised not to overdress because, with activity, body heat production increases. Perspiration should always be avoided. The body is unable to check the flow of perspiration water to the skin surface when skin temperature rises to about 95° F. The resultant flood of moisture dampens the clothing and tends to cool the body by added conduction. This will continue even after the need for sweating has ceased. Personnel exposed to cold conditions should learn to estimate their clothing needs in terms of environmental conditions and expected degree of activity, should attempt to underdress rather than dress for inactivity, and be prepared to take immediate steps to facilitate cooling by increased ventilation when body heat rises above the comfort level. This latter may usually be accomplished by baring the hands, which act much as an automobile radiator in cooling.

(3) *Wind and water resistance* normally is a function of a third clothing layer. Approximately 75 percent of potential heat loss from the body may be due to an increase in air movement. The most effective means of reducing this loss is by creating a shell which is more or less impervious to wind. A long-staple cotton fabric of dense weave is the most efficient fabric for such purposes (fig. 8).

A windproof garment reaches optimum efficiency with a combination of thin pliability, minimum weight, and a density just short of moisture imperviousness. A windproof garment may be made water-repellent but should never be made *waterproof*, because in the latter

FIGURE 8.—For wet and windy weather, the illustrated garments are worn over the special winter clothing shown in figure 7. The trousers and parka-type jacket are made of very tightly woven material, which while not entirely waterproof in the same degree as oilskins, is far more satisfactory because the material "breathes"—allows body moisture to be transferred out—but at the same time breaks the force of the wind and prevents water from saturating the insulative layers of garments. (Outfit from Bureau of Ships; photograph by Bureau of Aeronautics.)

case water of perspiration will accumulate in large quantities inside the clothing.

Aviation Clothing.

The problems of aviation clothing involve most of those associated with general heat and cold protection, as well as a multitude of conditions peculiar to aircraft operations. These include: Weight, bulk, resistance to flame, floatation, ease of putting on or taking off, integration with equipment, ability to protect against temperature extremes, limitation of normal activity, protection afforded when forced down, and the like.

While heating of the aircraft interior remains a possibility, for practical purposes the burden of air-crew protection from cold is a matter of clothing technic, involving unheated and heated types.

Unheated insulative clothing derives its main advantages from the independence afforded each crew member from all outside heat sources under all conditions, including forced landings on cold terrain. It is frequently difficult to adjust clothing worn to the amount required by widely varying conditions. This is most acute in the case of the pursuit pilot who must don clothing on the ground—under conditions perhaps quite warm—which will protect him at high-altitude temperatures. Perspiration accumulates at ground level temperatures, making the garment uncomfortable and inefficient when cold is encountered.

Shearling—sheepskin with the wool inside—while long the main reliance for aviation suits, in actual service is at a disadvantage because of its excessive weight and bulkiness, its stiffness, relative impermeability to water vapor, and the difficulty of drying because of the neces-

sity for coating the outside for durability. Manufactured clothes, such as cotton and wool pile, seem to be as effective in insulation and facilitate mobility of the wearer and "breathing" of the garments.

The normal reaction for a fighter pilot is to desire freedom of movement even if he gets cold. The best present padded suits, with all of their bulk, can protect at most to around +20° F. for approximately 6 hours. Below this temperature, and for longer periods, body-heat production must be increased. This process is complicated by the fact that it necessitates an increase in oxygen consumption and because of confined quarters it is not possible for all air crew members to exercise to the extent necessary to maintain heat balance.

Figures 9 and 10 illustrate lightweight Navy flying clothing. Figures 11 and 12 are photographs of the shearling, heavy insulative Navy flying outfit.

Heated aviation clothing permits reduction in bulk and protects against extremely low temperatures. Heat may be supplied from two sources—by circulation through the suit of air warmed by the engine; and by means of an electrical inner lining, with energy taken from the plane's power plant.

Electrically heated clothing appears to hold much promise, being used with varying amounts of insulative clothing. However, inadequate protection is afforded in case of failure of the power supply, or in case of forced landing and abandonment of the ship on a cold terrain. A substantial amount of electrical energy is needed for each suit at extremely low temperatures, even when moderate insulative clothing is used. In the case of air heating, danger of carbon monoxide poisoning is a factor, and in both types aviators balk

FIGURE 9.—Navy pilot's light-weight summer cover-all. (Photograph from U. S. Naval Air Station, Anacostia, D. C.)

FIGURE 10.—Medium-weight Navy leather flying jacket and helmet. Worn with regular blue denim work outfit. (Photograph from U. S. Naval Air Station, Anacostia, D. C.)

FIGURE 11.—Aviator donning suspender-type trousers of standard heavy insulative flying outfit. These are of shearling, fastened by zippers, and worn over regular clothing. Note the fleece seals at ankles and waist. These merge into the similar linings of boots and jacket to provide a cold-proof seal. (Photograph from U. S. Naval Air Station, Anacostia, D. C.)

FIGURE 12.—The complete Navy standard two-piece aviator outfit for normal high-altitude flying. Boots are equipped with a special zipper release for quick removal if forced down in water. The outer skin of the shearling is coated and quite impervious to air. With the wool lining and with woolen underwear this disadvantage, however, may be largely overcome and a considerable amount of perspiration absorbed. (Photograph from U. S. Naval Air Station, Anacostia, D. C.)

FIGURE 13.—The electrically heated flying outfit of the Navy for use in extreme cold conditions and for long-range, high-altitude flights. The suit is one piece of coated leather, with an inner lining containing the heating grid. Gloves of the five-fingered type connect into the heating circuit by means of two snaps. (Photograph from U. S. Naval Air Station, Anacostia, D. C.)

FIGURE 14.—Air crewman fully attired in electrically heated Naval aviator's suit, showing electrical connection and master switch. (Photograph from U. S. Naval Air Station, Anacostia, D. C.)

somewhat at the necessity of external connections between their clothing and the plane. Figures 13 and 14 illustrate the Navy's adaptation of the electrically heated air crew outfit.

Special Clothing Problems.

Protection of the extremities is more difficult than protection of other parts of the body, yet adequate provisions must be made if total body protection is not to be undermined. Principles for keeping *the feet* warm may be summarized:

(1) Keep feet dry; foot coverings for use in temperatures above 0° F. and under wet conditions are usually snug-fitting and waterproofed. Perspiration is only of secondary consideration, since there is little danger of socks freezing. One or more pairs of woolen socks, preferably ribbed for greater elasticity, are indicated. They will take care of insensible perspiration. Socks should be thoroughly dry before they are put on. The standard Navy arctic is illustrated in figures 7 and 8.

(2) Under extremely cold and dry conditions (below 0° F. with a slight breeze) footgear precautions shift radically from an attempt to keep moisture from entering, to an attempt to conduct moisture outside or to facilitate absorption within. Thus oil-tanned or waterproofed shoes and boots, impervious to water, are contraindicated. Experience in the polar regions, and the customs of the Russians, Canadians, Eskimos, and other northern peoples tend to the use of dry tanned leather, felt, burlap, and other similar materials. Most successful is the Eskimo mukluk. In this the sole and toe consist of a dry tan leather which remains flexible in the coldest weather. The upper, about 12 inches long, is of burlap. This is worn over two or more pair of woolen socks, between each of which is a felt inner sole. The outer covering is kept in place by tie strings loosely wound spirally and fastened above the calf. Under wet conditions, a waterproof boot may be substituted for the outer.

(3) Large, roomy, cold-climate footgear is essential. Any constriction will cause a decrease in the blood circulation, which circulation is of course the prime factor in maintaining body heat in the feet.

(4) Feet are especially subject to freezing. As long as easy movement is had and the sensation of cold is acute, freezing is not imminent. If cramping prevents movement of the toes, and if pain of great intensity lets up without undue reason, the feet should be promptly examined. Circulation arrested by freezing or frostbite can be restored by placing them next to warm flesh.[5] Never treat by rapid heating over a stove, by rubbing with snow, or by any strong abrasive handling. Such treatment tends to aggravate the condition and to abrade the skin and set up conditions for infection. Frozen toes should be cupped in warm hands, and gentle pressure and release of pressure should be applied until normal circulation has been restored.

Basic principles for protecting *the hands* under cold conditions are similar to those for the feet:

(1) Avoid lengthy exposure, do not touch metal, snow, etc. Keep the wrists, back of hands, and palms covered as much as possible.

(2) Use loose fitting woolen mittens, with separate wind-impervious coverings. Avoid use of gloves that separate the fingers, since radiation between the fingers is an important heat source.

(3) Chilled hands frequently are the result of overheating of the rest of the body and of constriction, which prevents proper circulation of the blood. Avoid the use of garments fitting tightly on the inside of the upper arm or under the armpits, where large blood vessels come near the surface.

(4) Keep the hands and hand gear as dry as possible, since moisture increases conductivity. Changing mittens when hands and mittens are wet and cold will immediately produce a feeling of warmth.

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[5] See also chapter XIX, "Hygiene in Aviation," for further information regarding frostbite.

(5) Freezing of hands is treated as described for feet, i. e., stimulation of circulation by gentle massage by warm hands, or of placing the hands next to warm flesh under the armpits, between the thighs, or next to the abdomen.

The head, particularly the face, is adapted to withstand a greater change of external climatic conditions than the body as a whole. The vital areas to be protected in their probable order of necessity are:

(1) The ears, because of their thinness, poor circulation, and exposed location, are susceptible to quick and painful freezing. Even in moderately cold weather, earmuffs are indicated, even though the rest of the head may be uncovered.

(2) The back of the neck must be protected because of the vital sensory nerve cords and tendons which lie close to the surface. The temples, forehead and throat, because of superficial blood vessels, must also be protected.

(3) The top of the head—when normal hair is present—will be safe without covering down to about 0° F. if no wind is blowing, although a light covering is preferable. Air crew personnel can usually keep their heads sufficiently warm, even under severe conditions, by an outer leather helmet over the cloth inner unit (figs. 9 through 14). The chief problem is that of providing comfortable support for ear phones, microphone, oxygen mask, and goggles.

(4) The chin will withstand a considerable range of temperatures, but when the wind is strong it requires protection. Similarly for the nose and cheeks, but as in the case of the mouth and eyes they are difficult to shelter. Face masks are used in severe weather (figs. 7 and 8).

(5) The eyes offer special problems. Snow-blindness is particularly serious. No matter how strong a man may consider his eyes to be, he will succumb to snow blindness and perhaps permanent injury to his eyesight if he does not take suitable precautions. Snow blindness is caused not only by direct sunlight on the snow, but also by diffused light on a cloudy day. Polaroid glass does not help, especially since light is reflected from many planes. Goggles issued with Navy winter clothing (figs 7 and 8) are suitable for cold weather use. Glare from the sun and water

in tropical regions may be somewhat mitigated by dark glasses. The antiflash eye shield in amber color (fig. 16) is being used by some Navy personnel.

(6) Freezing of the flesh about the face or head may proceed so quickly as to go unnoticed. At the moment of freezing a sharp twinge of pain shoots through the affected part, and it suddenly blanches white. The unwritten law, in cold countries, requires that each man call attention to his companion's face whenever he sees the appearance of an ashen area of freezing.

Protection against gas, flame, flash.—Gas-protective clothing usually consists of an over-all impregnated covering, with impregnated woolen socks and gloves, rubber overshoes and a gas mask. In emergency, almost any type of clothing which covers the entire body and is of relatively close weave may be impregnated and used more or less successfully.

Efficient flame-resisting suits which will enable damage-control measures to be taken promptly and effectively are necessities. The Navy's present fire-protection equipment is illustrated in figure 15. It should be noted that the rescue-breathing apparatus is worn on the *outside* of the suit. The rubber face piece of the apparatus should be worn under the hood of the suit, the corrugated breathing tubes protruding through the hole in the hood, with the bag outside. When the breathing apparatus is not used, an asbestos flap covers the hole in the hood.

A major and relatively new type of casualty which has made its appearance in World War II is "flash burn" from exploding bombs, explosions, and fire. Such burns were of primary concern after the Pearl Harbor attack and have been prominent in practically every action. The extent of burns is directly related to the covering afforded the body by clothing, since the injury is caused

FIGURE 15. — The flame-resisting suit of the Navy is equipped with an efficient rescue breathing apparatus, and is considered indispensable in fire fighting for gaining access to compartments under severe fire conditions and for taking damage control measures. This outfit is light, not having wire inserts, and for practical purposes entirely fireproof. (Photograph from Bureau of Ships.)

FIGURE 16.—Antiflash protection is currently afforded personnel by use of this outfit, consisting of long, gauntlet-type gloves and hood made of cotton, a gauzelike mask, and a plastic eyeshield. It is fundamentally important that all portions of the body be completely covered. The neck-apron may be worn under the blouse. (Outfit from Bureau of Ships, photograph by Bureau of Aeronautics.)

by a sudden instantaneous but intense wave of radiant heat, not by prolonged intense heat or actual flame. Thus short-sleeved shirts, open collars, and shorts are in distinct disfavor.

Flash burns at first sight rarely seem serious, appearing merely to be a slight searing of the skin. However, several hours after the blast the victim is usually found to be suffering from severe physical shock. He may lose control of the injured parts, and death may quickly supervene.

The Navy antiflash outfit is illustrated in figure 16. It consists of long, elbow-length gauntlet-type gloves and hood made of lightweight cotton, a stiffened gauze "bib" to protect the mouth, and a plastic eye-shield. Any type of other clothing may be worn, providing all areas of the body are covered. In action all personnel should be protected.

The British—whose outfit is essentially similar and in fact is the forerunner of this outfit—report that in spite of the discomfort naturally associated with the outfit, little difficulty is encountered in enforcing its use, especially with personnel who have seen action. American experience has apparently not followed this pattern. Care should be taken to see that clean outfits in good order are at all times available for instant use by all members of the crew in exposed quarters.

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Chapter VII

GENERAL DUTIES OF THE MEDICAL OFFICER OF A NAVAL VESSEL—ESSENTIAL MEDICAL DEPARTMENT REPORTS

All medical officers ordered to ships and those already aboard ships should refresh themselves on chapter 7, sections 2 and 3 of the Manual of the Medical Department, U. S. Navy. Here the duties are outlined and laid down in detail. They are practical and will be found to fit themselves into an effective routine, adherence to which will provide an efficient ship's Medical Department. The following comments constitute an attempt to apply these instructions.

The working day begins with morning sick call which should be expedited within the limits of safety, in order that as many as possible may be returned to their divisions prior to muster for quarters. Minor ailments and repeat dressings may be seen, and their treatment outlined to be carried out by a corpsman. Thus a great percentage of what appears to be a large sick call may be handled in a relatively short time. Cases seen for the first time, or those not progressing properly, will require more careful inspection and study, hence will take up more time. Ear, nose and throat cases require close scrutiny, as it is here one can hope to limit the spread of the common cold, and perhaps to observe early signs of acute contagious diseases. For this reason all

drafts of new men reporting aboard are to be routed to the sickbay by the officer of the deck and examined for venereal or contagious diseases.

Following completion of sick call a careful inspection of the ward and other sickbay spaces is made. Any special work for the corpsmen is outlined, and the medical officer may proceed to the sanitary inspection of the ship (ch. VIII). It is well to do this in a deliberate manner observing not only sanitation, but any hazards which might lead to injury of personnel. The general welfare of the men may be bettered by the efforts of an interested medical officer who is observant. He can give helpful suggestions to the executive officer on improved living conditions. Minor insanitary conditions existing can usually be remedied in the department involved by cooperation with those responsible. Where resistance is encountered, and in the more flagrant breaking of rules, report is at once made to the executive officer and with his cooperation the situation is remedied. It should be kept in mind that the executive officer is responsible to the captain for all the detailed upkeep of the ship and any minor details that can be remedied by department heads relieves him to that extent.

Morning reports for the medical department on board ship can only be completed after sick call. They constitute a written report and summary of the health of the ship to the captain and all department heads. Promptness in submitting the morning report of sick, binnacle list and muster report is expected. Careful checking by the medical officer of these reports obviates embarrassment later due to incorrect impressions conveyed by errors.

Physical examinations are frequent, consisting of those for promotion, reenlistment, confinement, and study of cases. So far as possible these should be worked in with regular routine, but when they present in large groups they must be planned or scheduled. In wartime all these extras require careful planning both from the standpoint of medical officer and examinee, to avoid conflict with important war watches.

Instruction of hospital corpsmen must be a continuous activity and in general is best given in the afternoon. Instruction schedules made out on a weekly or monthly basis are practical, and allow men to prepare in advance of the instruction period. These periods can be made interesting by delegating part of the instruction to senior corpsmen who through special training or long practice are able to present a subject properly. Effort should be made to relieve all men from duty who can be spared for this period, providing only a skeleton crew for the hour or two required.

First-aid instruction for the crew is best organized by divisions and in many cases can be arranged as part of the general instruction period held by division officers. In wartime it is sometimes necessary to give instructions to groups while they are on watch at the guns or on other stations. This should be done with the help of well-trained corpsmen in order that all members of the crew receive the fundamentals of first aid soon after joining the ship, and will thus be prepared for action. In combat zones it is found that all personnel soon become first-aid conscious and will cooperate in every way with the Medical Department in its attempt to disseminate knowledge along those lines. Thought and application to this instruction are necessary in order that

it may apply to one's particular ship and to one's particular problems as they arise. Experience shows that oftentimes lives are saved by the first persons reaching the wounded, hence the imperativeness of first-aid instruction to all hands.

Daily physical exercise, such as setting-up exercises for the crew, requires much consideration. It is difficult under war conditions to have any large percentage of the crew present at a stated time daily for such drills. However, it has been found practical and beneficial to divide the ship's company, by divisions or departments, into three or four sections and rotate these sections. In this manner all men are given some exercise in the fresh air twice weekly, and are further urged to spend some time on deck each day.

Battle organization, dressing station equipment, first-aid boxes, etc., are described in chapter XI.

Maintenance of property and property returns are duties to be delegated to the chief pharmacist's mate or the senior corpsman. It is necessary for the medical officer to devote considerable time to this detail in order to indoctrinate an assistant in the proper estimation of the needs of the department, storeroom upkeep, and issue of supplies.

Careful checking of health records is necessary and should be done against the ship's muster roll to insure that all records are on board. To check them carefully on arrival for inoculations and vaccinations is a practical method of keeping them up to date. Missing records should be requested from the last station at once, and all health records should be forwarded promptly upon detachment of personnel. Identifica-

tion tags are to be made for all who do not already have them, and notation made in the health record.

Care of the dead is a responsibility of the medical officer. Embalming, preparation of report of death (Form N) and proper handling thereafter is carefully outlined in the Manual of the Medical Department. In wartime some variations from the standard practices, such as burial at sea, are authorized and are outlined in Bureau letters and instructions. Divisional officer duties are to be the responsibility of the junior medical officer or dental officer; depending on the number of officers in the department this detail should be rotated and at all time supervised by the senior medical officer.

Essential Medical Department reports are enumerated in part and briefly discussed as follows:

Health record—all entries are to be made promptly and to be complete with signature of medical officer where required.

Hospital ticket (Form G)—upon transfer of patients.

Morning report of sick—submitted daily.

Binnacle list—may be combined with morning report of sick.

Daily muster report—required on most ships by the executive officer, shows presence or absence of all Medical Department personnel.

Medical Department Journal—daily entries of all important activities in the department and signed by the medical officer on duty.

Treatment book—provides for entries of all patients treated, with their disposition.

Prescription files—to be kept up to date in the pharmacy, with separate file for narcotic prescriptions.

Narcotic book—to be maintained at all time ready for inspection and checking with preparations on hand.

Alcohol book—entries to be made at time of expenditure.

Ward book—list of patients with orders listed for each; to be signed daily by the ward medical officer.

Laboratory book—showing all laboratory procedures under proper dates with a record of the findings.

Dental appointment book—maintained by the dental corpsmen under the direction of the dental officer.

Venereal treatment book—listing all treatments and orders as given by the medical officer in charge.

Hull report—a weekly report to the first lieutenant's office regarding structural condition of medical department spaces.

Form F cards—to be made up on admission of a patient and completed at time of discharge.

Monthly Form F—smooth form made up from the F cards, for purpose of compiling statistics.

Monthly report of venereal diseases and treatments given—includes record of any untoward reactions, which may serve to detect a faulty shipment of material.

Communicable disease report—submitted monthly.

Special reports—may be made to the Bureau and to the fleet surgeon at any time regarding unusual occurrences, and must be submitted in the presence of an epidemic.

Allotment reports (*Form B*)—are submitted quarterly for financial purposes.

Surveys of Medical Department property—may be forwarded at any time.

Annual, other *monthly* and *quarterly* reports are tabulated in section 3552, Manual of the Medical Department. A check-off list of these should be maintained in the record office to insure prompt and complete returns from the department.

Bills of health, *pratique*, etc., are discussed in chapter XXIV.

Procedures outlined in this chapter may be applied to all types of Navy ships. On small ships the problems are proportionally less in number and smaller in size. The organization must always be built on the complement allowed, and should be enlarged as demands require. A less complex organization is more easily expanded and can be better supervised, and therefore is to be desired at all times.

Chapter VIII

SANITARY INSPECTION OF THE SHIP

To maintain a ship in good sanitary condition requires routine inspections by a medical officer, supplemented by a sense of good housekeeping instilled into the minds of all hands. To accomplish this it is necessary for the executive officer, first lieutenant, and medical officer to cooperate in all matters pertaining to life aboard the ship.

Routinely it is the duty of the medical officer to inspect the galley, scullery, ship's service store, pantries, living and messing spaces, brig spaces, heads and wash rooms, and, of course, sickbay, daily.

In the galley the necessity for a close supervision is dependent upon the morale of the commissary department. All supply officers are well versed in the quality, storage, preparation, and handling of food; and will insist upon scrupulous cleanliness on the part of the galley personnel.

A copy of the week's menu for the general mess passes over the desk of the medical officer usually on Friday or Saturday for the following week. Here the medical officer has his opportunity to observe quantity, balance, and sufficiency of the ration. He should observe in this menu whether there are foods to be served which require special precautions, such as cold meat, salads, hash, and cold beans. All of these require pre-

cautions. Meats served on the second day after cooking are just as good as are the methods of refrigerating and handling, but no better. In a well-organized galley, meats for salads are cooked early the day of use; the same will apply to hash and the use of cold beans. Exceptions may be made in the interests of economy, but close supervision is required to prevent spoilage, and climatic conditions must be considered as a guide to procedure.

All meats used on board ship—except in emergencies—are Government inspected and are so marked. Due to the time interval involved, one must guard against relying entirely on this procedure, and all doubtful appearing meat noted in the galley should be referred to the medical officer for his inspection. Tinned meats are used more and more. Generally speaking they keep well, but tinned hams will at times show signs of softening and even liquefaction in some areas, which unfit them for use. Economy is necessary but dangers of contaminating an entire meal are not to be compared with the discarding of a few items of food in that meal.

All fresh foods, which are often obtained from local sources, must be inspected by some member of the Medical Department. This may oftentimes be the duty of an experienced corpsman who is instructed to notify the medical officer at any time there is a doubt regarding the quality of the supplies. Milk, ice cream, and seafoods require close watching, and a knowledge of the source of the supply is often helpful in determining their qualities. Local health regulations and reports are usually reliable as to the dairy products in a com-

munity, and should be used by the ship's medical officer for guidance.

Galley spaces are inspected for general cleanliness of material; all utensils and machines used in the preparation of food should be closely watched. Meat-slicing machines, if not properly cleaned, may be a source of food tainting or spoilage.

The butcher shop is usually a matter of pride to the commissary officer; it can be maintained in a neat, clean, and orderly fashion at almost all times. Meat blocks require careful scraping and cleaning, and are usually covered with a layer of clean salt to remove excessive moisture and to prevent development of odors.

The spud-peeling and vegetable room is difficult to maintain in a neat condition, but reasonable cleanliness must be maintained. Cold-storage spaces must be inspected at weekly intervals, and at any other times as indicated by break-downs or doubtful food preservation. Here it is difficult to avoid moisture, but cleanliness in appearance and a minimum of odors can be maintained. Washing down with soda water will often remove undesirable food odors as well as cleanse.

Personnel inspection of all food handlers on the ship excepting the breakout men should be carried out weekly. This involves at times careful organization and cooperation with the commissary officer and master-at-arms, but can be arranged so that all men are present for inspection. Remember the man who is too busy to appear for inspection may be the one who is harboring a venereal infection. Throat, skin, and venereal infections are to be looked for on these inspections.

The scullery is of particular interest to the medical officer as it may be the point at which the spread of

disease is interrupted, or through inefficiency it may be the source of an epidemic of disease. It is directly under the first lieutenant, who more or less delegates its operation to the chief master-at-arms. Men assigned here for duty are taken from all departments of the ship and most often are men least experienced in life aboard ship. Their stay is often limited to 1 to 4 months; hence there is a constantly changing force.

Ships provided with a modern dish-washing machine and sterilization tank can maintain a sanitary scullery. With the cafeteria system of feeding which prevails, there are fewer dishes to handle, thus reducing chances for individual contamination. Aluminum trays may be readily sterilized, carefully dried in air, and stored for the next meal with no handling by individuals. Thorough cleansing with hot water and soap powder in the washing machine prepares them for the sterilizing tank. Here they withstand a temperature of 212° F. or above for the 3- to 5-minute period without harm. A recording thermometer connected to the sterilization tank is an excellent safeguard and shows the temperature of the water in the tank during the hours of operation. It is strongly recommended for all sculleries.

Ship's service stores which manufacture and sell ice cream require close supervision. These stores are always under the supervision of a commissioned officer whose duty it is to maintain them in good working order. Sanitary conditions must be maintained and personnel working in the store must report for inspection with other food handlers. For ice-cream manufacture, dry mix is used at sea. In port wet mix is often obtained from a local dairy and is frozen aboard. Dry mix is put up in sealed tins and keeps for long

periods of time without deterioration. Wet mix must be carefully handled and of course kept in cold storage until used. In either case samples of the finished product should be submitted for laboratory examination at times to guard against all breaks in methods of preparation.

Pantries for the various officers' messes are inspected daily. Dependent upon the efficiency of the mess treasurers and the help provided them, they are kept in good or poor sanitary condition. Again with rapid expansion, men of less experience and training will be used and it is incumbent on the Medical Department to be more than ever on the alert during inspections for cleanliness. Presence of food particles in cracks and crevices leads to the attraction of roaches which so often invade pantries. Constant attention to thorough cleaning after each meal, supplemented by occasional spraying with Navy insecticide does much to eliminate this evil.

Ice boxes should be inspected for cleanliness and for proper temperatures. Certain foods should be stored in separate compartments to avoid complaints regarding mixed flavors which are often interpreted as harmful contaminations. Butter will absorb flavors from other foods, rendering it unpalatable.

Small dish-washing machines are desirable for pantries, but are not available on all ships. Hence constant indoctrination must be carried on to impress the stewards and mess boys with the importance of proper dishwashing. Facilities for washing hands should be available either in or near all pantries. Mess boys should frequently wash their hands while working about pan-

tries and serving food. This is doubly important in warm climates where they are handling ice for cold drinks in the wardroom. The question of proper handling of left-overs here is an important one as stewards attempt all sorts of economies to maintain a reasonable mess assessment. The medical officer must be vigilant and at the same time as helpful as possible in solving these problems.

Responsibility for cleanliness in living spaces and messing compartments is primarily that of the division officer. He may at times need helpful suggestions from the medical officer and this should be freely given. Hammocks should be swung on a minimum of 3-feet-centers, and alternate men should sleep with heads in opposite directions. Bedding should be aired at not too long intervals, depending on weather conditions. While being aired—on upper decks usually—it should be inspected by the medical officer for cleanliness, state of repair, and infestation. A mattress showing bugs, or evidence of bugs having been present, should be traced to its bunk frame and a proper search made for bedbugs. This procedure at times may lead to the location of an entire compartment infested with bugs. Remedies to be used emphasize the sterilization of all infested mattresses if a large autoclave is available. If none is available the mattresses should be sprayed frequently during a period of 1 week. Spraying in the compartment, supplemented with the use of a blow torch on metal frame and springs will usually control the situation. Remember this is a time when treatments often require repetition and perseverance on the part of your sanitary squad or corpsman. Carboxide gas is a deterrent, but cannot be looked upon as a sure remedy for bed-

bugs. Painting for the sealing of cracks is helpful. Any method used must be followed up closely and an attempt made to limit the spread of the infestation.

There is a marked tendency to overcrowd berthing and messing spaces over the designed capacity during wartime conditions. Ventilation has, of course, fallen below standard with the elimination of ports, and this must be compensated by artificial ventilation, which, is often a problem. During wartime with ships darkened at night necessitating the closing of ports (if present) and outside doors, forced ventilation by blowers must be used. Blower motors will only stand a stated speed for continuous operation, and do not attempt to have them operated over that speed. Sometimes by installing a portable blower or fans, a situation may be remedied or helped. Ships are constructed with a definite ventilating system which is difficult to alter on short notice. The minimum ventilation standard is 30 cubic feet per man per minute, plus an added volume to reduce heat. Where wild heat is present, as from adjoining machinery spaces, 40 cubic feet per man per minute is required.

Heating presents some problems, but is usually controllable by proper inspections and the taking of temperatures in various locations in the ship. The slogan here should be to under rather than over heat. Cooperation with a representative of the engineers' force should solve most of the heating problems. (See ch. II, Ventilation.)

Lighting requires some supervision, but again, it is built into the ship and if not the victim of too many changes and too much economy is usually adequate for all purposes. Seats in the living compartments should

be near proper light in case men wish to read. (See ch. VI, Lighting.)

Drinking fountains on modern ships are conveniently located and adequate. Their operation is dependent upon the engineers' force and are usually well maintained.

Brig spaces are to be livable but not luxurious. Adequate ventilation and light along with cleanliness is all that can be required in these spaces.

Heads or toilets should be inspected for cleanliness, proper flushing facilities, and the best ventilation obtainable. The flushing is accomplished in the crew's head by a constant flow of salt water in sufficient quantity to prevent stagnation. Any interference with this system should be at once reported and remedied. It is well to set aside one stall for venereal patients and have it so marked. This provides mental relief for the individual who fears contracting a venereal disease from a toilet.

Toilet and lavatory facilities should approximate the following:

Toilets: One per 20 men.
Urinals: One urinal or 1 foot of trough for each 25 men.
Showers: One per 25 men.
Lavatories: One lavatory for every 5 men.

Proper scrubbing of seats, which are removable, should prevent the spreading of crabs (*Pediculus pubis*).

Urinals are prone to be odorous. Increased flushing is about the only remedy along with the deodorant cakes which merely serve to change the odor.

Washrooms present little difficulty to the medical officer except to see that they are kept clean, and open

sufficient hours per day for all men to keep clean. Whether showers are provided or not, it is found that most men use the washrooms and bathe daily.

Laundries are to be inspected for proper methods of operation, mainly to determine that sufficient hot water and soap are used to insure cleanliness. Laundry from contagious cases is to be treated in the sickbay prior to sending it to the general laundry. Either live steam, autoclave, or solution of cresol should be used for this purpose. Laundries are usually located in closed spaces, which fact associated with the steam and hot water used, produces very high temperatures. Personnel working here should be observed at intervals for general health, and where possible, additional exhaust ventilation provided to lower the temperature and humidity in the space.

Barber shops on the ship should be inspected for proper sanitary precautions. Post a list of precautions to be taken as to working on men with skin lesions, or men who are manifestly ill. Proper sterilizing facilities should be available and inspections repeated to see they are being properly used. All barbers are to be inspected at weekly intervals for cleanliness and personal health. Blood Kahns are to be taken before allowing new men to begin work, and checked as indicated after that time.

Inspection of sickbay spaces requires little comment. Here the character of the medical officer is reflected more than in any other part of the ship. It should be clean and orderly at all times, and maintained with a spirit of cheerfulness made possible only by proper selection of ward master and thorough indoctrination by the medical officer. Constant alertness for conta-

gious diseases must be practiced and, when noted, proper methods of isolation instituted. Cubicle isolation has been found to be effective on ships affording no isolation ward, but must be strictly supervised.

Venereal inspections of the personnel are indicated at times, governed by the areas in which the ship is operating. Conditions in general are reflected in the local health departments, and these records should be consulted. Surprise inspections are time-consuming and if not properly organized may be very upsetting to the routine of the ship. Much can be accomplished by proper observation of all men reporting to sick call, as this group constitutes a good cross section of the personnel. If the medical officer has the confidence of his personnel, obtained through tact and a proper professional interest in their condition, concealment of venereal or any other diseases will be maintained at a minimum.

Instruction as to venereal disease prophylaxis must be repeated frequently. Printed instructions which may be read to divisions by division officers or hospital corpsmen when ships are entering port, are practical and cause little interference with ship's routine. This is best accomplished at a regular quarters-for-muster formation.

Chapter IX

THE SICKBAY AND HOSPITAL SPACE AFLOAT

The sickbay and hospital spaces found in our naval vessels of today evolved from their predecessor, the cockpit of the early British and American ship of the line.

A corresponding evolution has taken place in the Medical Department equipment, supplies, and personnel provided in our present-day ships. In contrast with the traditional equipment and crude surgical methods, including the ministrations of the "loblolly boy," the Medical Department facilities of a combat ship today are equipped to provide care for the sick and injured of the type found in hospitals ashore.

The planning and arrangement of hospital spaces in naval vessels will never remain static, being dependent on changes in ship design and variables in the methods of medical and surgical practice. A description of today's Medical Department aboard ship, therefore, probably will not be applicable for any great length of time.

The scope of the Medical Department facilities provided in a vessel is also dependent upon the complement of attached personnel and the mission of the ship. Thus, in a submarine, or a small surface ship, medical care is rendered by a pharmacist's mate, with a min-

imum of equipment and supplies; while the larger combat ship or transport, with her medical officers, dental officers, hospital corps officers and men, and the superlative type of equipment and supplies now available, is in a position to render complete and definitive hospital care and treatment.

Hospital ships have been developed to the point where the Medical Department spaces provide facilities which are the full equivalent of a hospital ashore. Complete surgical, medical, ear, eye, nose and throat, x-ray, laboratory, and dietetic facilities are included. The *sole* mission of these ships is the care of the sick and wounded, which permits them to operate under the terms of the Geneva Convention.

Certain vessels are designed or designated for the transport and care of large numbers of casualties as an incidental mission of these ships. They are not hospital ships but are classed as hospital transports; they are ships used for the evacuation of the sick and wounded to areas where full hospitalization is available.

In discussing the layout of hospital spaces aboard ship it will be obvious that each ship or class of ships presents an individual planning problem. It must be decided, on the basis of attached personnel, mission, and design of the ship, what should be provided and what may be accomplished in the arrangement of the hospital spaces. The Bureau of Medicine and Surgery has always maintained an active liaison with the design section of the Bureau of Ships. This has contributed greatly to bringing about many improvements in the arrangement and fixed equipment of the hospital spaces afloat. It is not always possible to have the most de-

sirable location for sickbay and hospital spaces but by compromise and adjustments in design it is usually possible to provide at least suitable ones.

The number of bunks provided in the hospital spaces, as required under General Specifications for Building Vessels of the U. S. Navy (1936 edition), is fixed at 2 percent of the crew and 1 percent of troop berths. No specification exists for the lay-out or arrangement of hospital spaces, and plans must be developed to give the best possible functional result in meeting the requirements of each individual ship or class of ships.

The principal spaces and fixed equipment provided in a sickbay based on 30 sick berths are as follows:

Sick Berthing Spaces.

Sick ward.—Hinged berths are ordinarily arranged in tiers, two high, with a private locker for each berth. A suitable number of surgical beds is provided. Linen lockers, drinking fountains, and medicine cabinets are provided. Where possible a diet pantry and utility room are placed in spaces adjoining the ward. The ward head (toilet) should be adjacent and contains, in addition to toilets, showers, and lavatories, a sitz bath and soiled linen hamper. A bedpan and urinal rack or locker is also included in the head space if a utility room is not provided.

Quiet room.—At least one quiet room with private bath, toilet, and lavatory for seriously ill or for officer patients is desirable.

Isolation ward.—A separate space fitted with a suitable number of berths, with adjoining private head facilities, is provided for the treatment of communicable diseases.

Insane ward.—In certain vessels, depending on the ship's mission, an insane ward is provided. The fittings in this space are so designed that escape and possibility of injury are prevented. When possible, separate head facilities and a space for a continuous watch are included.

Sanitary standards of sickbay berthing spaces.—In the sickbay berthing spaces the following are considered as minimum standards:

Toilets: One per 10 berths.
Urinals: One per 10 berths.
Showers: One per 20 berths.
Lavatories: One per 10 berths.

Dispensary.—This space, corresponding to the pharmacy ashore, is regularly provided on all but the smallest ships and may be combined with the laboratory or clerical office. It is equipped with a drug cabinet with standard racks for bottles above, sink, and distilling apparatus. A Dutch door is provided for dispensing.

Bacteriological laboratory.—If possible, it is desirable to provide a separate laboratory for esthetic as well as medical reasons. The equipment for this space should be a single built-in unit to meet all needs in carrying out laboratory procedures aboard ship.

Surgical dressing room.—If space is available, the surgical dressing room should be a separate compartment large enough to accommodate the facilities for carrying out the bulk of routine sick call, examinations, treatment, and minor surgical procedures. This will permit the proper reservation of the operating room for clean surgical cases. The space is equipped with a folding type operating table, and recently developed surgical lights with four mounting brackets so that desired light-

ing arrangements can be made. A built-in surgical cabinet is also provided for the improved stowage of supplies and equipment. Other equipment, such as therapy lamps, diathermy apparatus, office sterilizers. or treatment chair may be provided for this space as desired.

Operating room.—When sufficient space is available for both a surgical dressing room and operating room, the latter is used for the exclusive treatment of non-infected and major surgical cases. Attention is given to the details of construction in this space in order to provide materials, equipment, and functional arrangements which will insure proper surgical cleanliness and methods of operating. The deck should be of suitable nonabsorbent material which can be easily cleaned. Electrical conductivity of the deck is usually not necessary to consider because explosive anesthetics are rarely used aboard ship. The operating room is not air-conditioned except under special circumstances where structural conditions make it necessary. The operating light consists of four surgical lights of 200 volts with 8 mounting brackets which permit various lighting arrangements. A built-in surgical supply cabinet is provided preferably flush with the bulkhead in order to eliminate dust-catching surfaces. A major type operating table, dressing and instrument stands, and hinged washbowls are installed. Means are provided for securing all loose equipment in a seaway.

Sterilizing room.—When possible a separate space for sterilization is provided in order to avoid the dissemination of steam and wild heat from sterilizers into the operating room. The sterilizer equipment usually consists of a combination pressure dressing sterilizer (auto-

clave) either 16 by 24 inches or 20 by 36 inches, a boiling type sterilizer 16 by 6 by 4 inches or 20 by 10 by 9 inches, and a hot- and cold-water sterilizer (usually combined in one tank) of 8 or 15 gallons capacity. The combination sterilizer may be either steam or electrically heated and it is frequently necessary to provide odd combinations of these units to fit the space available. A hood is installed over the combination sterilizer to carry off excess vapor. If space permits, a dressing cabinet with work counter is included in the sterilizing room.

Scrub room.—When possible a separate scrub room or scrub alcove is provided to adjoin the operating room. It is equipped with a standard scrub sink, soap container, and, if space permits, a small clothes locker.

X-ray darkroom.—This room is used for film processing and for storage of the "suitcase" type x-ray machine. A complete processing outfit, with cooling apparatus, work bench, and storage cabinets is provided.

Dental office.—Dental facilities are provided on the basis of space for one dental operating unit for approximately each 500 to 1,000 men of the ship's complement. Each dental operating space is equipped with a standard dental chair and unit, lavatory, small sterilizer, and instrument cabinet. A dental x-ray is provided. In addition, a built-in cabinet provides space for the air compressor, supplies, records, narcotic safe, etc. A complete and compact prosthetic unit has been designed for ships requiring dental prosthetic equipment.

Venereal treatment room.—This space is provided for venereal prophylaxis and treatment. Straddle stands, prophylactic locker and lavatory are provided.

Examining room (aviation).—A space is provided in

aircraft carriers where the special examinations required for aviation personnel can be conducted. This space, if possible, should be 24 feet in length and fitted with such special equipment as the Bárány chair and a phorometer.

Doctor's office.—A doctor's office is provided for purposes of administration and private consultation. It may be equipped with desk, files, bookcases for medical reference books, and facilities for conducting limited physical examinations.

Clerical office.—This space is fitted with the necessary furniture and equipment for carrying on the clerical work for the Medical Department. If possible, the clerical office should be provided as a separate space. although it is frequently necessary to combine it with the doctor's office.

Utility room.—This space is included in large ships to provide proper servicing of sickbay utensils. A bedpan washer and sterilizer, utensil sterilizer, bedpan and urinal racks, soiled linen hamper, and cleaning-gear locker comprise the equipment furnished.

Medical storerooms.—It is important that adequate storeroom spaces be provided for medical supplies. There should be two or more such spaces located in as widely separated parts of the ship as possible in order to provide dispersion of materials. Available storeroom space is usually in the lower parts of the ship, so that it is desirable to have an issue storeroom located in the sickbay country. A ship carrying around 1,500 personnel should have a minimum of 2,500 cubic feet in the main medical storerooms, plus 500 cubic feet in the sickbay issue storeroom. All

storeroom spaces are fitted with metal shelving and bins.

Medical storeroom, destroyers.—The medical storeroom of a destroyer, more properly called the sickbay, is the victim of the crying need for space in these ships. The usual destroyer sickbay contains no berths, and the space allotted is hardly adequate to serve as a dispensary and for storage of supplies and equipment. In the present war operations the destroyer is frequently called upon to receive casualties, and a medical officer is aboard each of these ships. Besides the standard equipment of drug cabinet, boiling type sterilizer, and prone examining table, there has now been added a portable surgical light and a pressure dressing sterilizer. A prophylaxis locker is provided in the crew's head.

Battle dressing stations.—Battle dressing station spaces are provided for the emergency treatment of casualties during and following an action. These spaces are set aside and equipped with emergency surgical facilities in dispersed positions within the ship. The principal fixed equipment comprises a water-storage tank, hot-water heater, lavatory, hinged shelves for dressings, sterilizer, and storage space for supplies. A portable surgical light operating from ship's current or battery is valuable.

With changes in ship design incident to damage control it has developed that auxiliary dressing stations are necessary to care properly for casualties. These are provided in suitable locations, accessible to the ship's battle stations, and are equipped with material similar to that furnished at the battle dressing stations. (See ch. XI.)

CHAPTER X

MEDICAL DEPARTMENT ON BOARD SHIP IN EMERGENCIES OTHER THAN BATTLE

Naval personnel at sea are confined within the steel wall of ships where many emergencies may occur other than those caused by battle. To combat successfully these emergencies, coordinated and concerted effort on the part of all is required.

Emergencies which occur on board naval vessels frequently result in casualties both to personnel and matériel. The matériel casualties are primarily the responsibility of the damage control officer, whereas the transportation and care of personnel casualties is primarily the responsibility of the Medical Department.

To accomplish efficiently the mission of the Medical Department in these emergencies, careful planning followed by thorough indoctrination and drilling of all personnel is imperative.

For maximum efficiency, this planning and training should be coordinated with that of all other departments. To assure this, all watch, quarter, and station bills are prepared by the heads of departments concerned and submitted to the commanding officer for his study and approval. With this approval they become the standard practices.

The design and equipment of naval vessels render them more hazardous than their commercial sisters in carrying out their missions in peace and in war.

Listed among the more important additional hazards are:

1. Greater concentration of personnel.
2. Power plants of much greater magnitude and output.
3. General naval and military agents.
4. Special nautical hazards incidental to high speed and maneuvers in formation.

To provide for such possibilities, ship's watch, quarter, and station bills include sections on: (*a*) Fires; (*b*) collision; (*c*) fire and rescue party; (*d*) abandon ship; (*e*) man overboard; and (*f*) landing force.

The medical officer of the ship prepares the watch, quarter, and station bill for the surgeon's division.

A type bill is presented to meet these major emergencies. It covers the general principles of planning, organizing, and training for the specified emergencies.

All preparations aboard ship are now predicated on war, therefore emergencies of any nature are usually met from a general-quarters setup, which this bill provides.

Included are provisions for landing exercises either in preparation for war or to assist fire and rescue parties in such emergencies as may result from major catastrophies ashore, including earthquakes, fires, hurricanes, floods, etc.

Each ship is an entity in itself because of the type of ship, individual structural characteristics, personnel, and its mission.

The following is based on a complement of 3 medical officers, 1 dental officer, and 12 hospital corpsmen.

TABLE 5.—*Watch, quarter, and station bill—Officers*

Name	Rank	Fire [1]	Collision [1]	Fire and rescue	Abandon ship		Man overboard	General quarters			Landing force	Watches	
					"A"	"B"		Condition 1	Condition 2	Condition 3		Port	Starboard
Senior medical officer.	......	MBDS(SB)	MBDS(SB)	MBDS(SB)	[2]	[2]	MBDS(SB)	MBDS(SB)	[3]	[4]	......		X
First junior medical officer.	......	ABDS	ABDS	MBDS(SB)	[2]	[2]	Meet boat on its return.	ABDS	[3]	[4]	......	X	...
Second junior medical officer.	......	FBDS	FBDS	With party	[2]	[2]	MBDS(SB)	FBDS	[3]	[4]	Beach party.		X
Dental officer	......	FBDS	FBDS	MBDS(SB)	[2]	[2]	MBDS(SB)	FBDS	[3]	[4]	......	X	

[1] A medical officer and one hospital corpsman nearest the scene of fire or collision will report at the scene of emergency.

[2] All Medical Department personnel will assist in evacuating patients; thence to abandon ship station in accordance with ship's abandon ship bill.

[3] Medical Department personnel will be at battle dressing stations, maintaining communication watches and reducing personnel to *watch* and *watch*.

[4] Medical Department will maintain communication watches and carry on routine care of sick.

MBDS(SB)—Main battle dressing station (sickbay).
ABDS—After battle dressing station.
FBDS—Forward battle dressing station.
Abandon ship "A".—Rapid sinking; no time to lower boats. Life rafts launched where possible.
Abandon ship "B".—Slow sinking; all boats and life rafts made available.

TABLE 6.—*Watch, quarter, and station bill—Hospital Corps (Surgeon's Division)*

Bunk No.	Locker No.	Name	Rating		Fire [1]	Collision [1]	Fire and rescue
			Allowance	Actual			
		1st section					
			PhM1c	PhM1c	FBDS	FBDS	FBDS.
			PhM3c	PhM3c	1-TSP	1-TSP	With party.
			HA1c	PhM3c	MBDS(SB)	MBDS(SB)	MBDS(SB).
		2d section					
			PhM1c	PhM1c	ABDS	ABDS	ABDS.
			PhM2c	PhM2c	2-TSP	2-TSP	With party.
			PhM3c	PhM3c	1-DCP	1-DCP	1-DCP.
		3d section					
			PhM1c	PhM2c	FBDS	FBDS	FBDS.
			PhM2c	PhM2c	3-TSP	3-TSP	3-TSP.
			PhM3c	PhM3c	2-DCP	2-DCP	2-DCP.
		4th section					
			CPhM	CPhM	MBDS(SB)	MBDS(SB)	MBDS(SB).
			PhM2c	PhM2c	3-DCP	3-DCP	3-DCP.
			PhM3c	PhM3c	ABDS	ABDS	ABDS.

[1] A medical officer and 1 hospital corpsman nearest the scene of fire or collision will report at the scene of emergency.

TABLE 6.—*Watch, quarter, and station bill—Hospital Corps (Surgeon's Division)*—Continued

Bunk No.	Locker No.	Name	Abandon ship		Man overboard	General quarters			Landing force	Watches		Cleaning station
			"A"	"B"		Condition 1	Condition 2	Condition 3		Port	Starboard	
		1st section								*1st section*		
			(2)	(2)	MBDS(SB)	FBDS	(3)	(4)			X	
			(2)	(2)	With boat	1-TSP	(3)	(4)			X	
			(2)	(2)	MBDS(SB)	MBDS(SB)	(3)	(4)			X	
		2d section								*2d section*		
			(2)	(2)	MBDS(SB)	ABDS	(3)	(4)	X	X		
			(2)	(2)	Stand by	2-TSP	(3)	(4)		X		
			(2)	(2)	MBDS(SB)	1-DCP	(3)	(4)		X		
		3d section								*3d section*		
			(2)	(2)	MBDS(SB)	FBDS	(3)	(4)			X	
			(2)	(2)	MBDS(SB)	3-TSP	(3)	(4)	X		X	
			(2)	(2)	MBDS(SB)	2-DCP	(3)	(4)			X	
		4th section								*4th section*		
			(2)	(2)	MBDS(SB)	MBDS(SB)	(3)	(4)		X		
			(2)	(2)	MBDS(SB)	3-DCP	(3)	(4)		X		
			(2)	(2)	MBDS(SB)	ABDS	(3)	(4)	X	X		

[2] All Medical Department personnel will assist in evacuating patients; thence to abandon ship station in accordance with ship's abandon ship bill.

[3] Medical Department personnel will be at battle dressing stations, maintaining communication watches and reducing personnel to *watch* and *watch*.

[4] Medical Department will maintain communication watches and carry on routine care of sick.

MBDS(SB)—Main battle dressing station (sickbay).
ABDS—After battle dressing station.
FBDS—Forward battle dressing station.
1-TSP—No. 1, Topside patrol, etc.
1-DCP—No. 1, Damage control party, etc.
Abandon Ship "A".—Rapid sinking; no time to lower boats. Life rafts launched where possible.
Abandon Ship "B".—Slow sinking; all boats and life rafts made available.

Emergency Drills

The paramount duty of the Medical Department is the prompt response to and comprehensive action in the various emergencies. Therefore the surgeon's division must be indoctrinated and drilled until their state of training is thoroughly adequate and so maintained.

Fire Bill.

Alarms.—

1. Word passed over loudspeakers, giving location.
2. General alarm.
3. Rapid ringing of ship's bell followed by *one*, *two*, or *three* strokes to indicate whether fire is *forward*, *amidships*, or *aft*, respectively.
4. "Fire Quarters" sounded on bugle, followed by *one*, *two*, or *three* blasts to indicate location.
5. Word again passed over loud-speakers.
6. "Commence Firing" on bugle is the signal to turn on water at scene of fire.
7. "Cease Firing" is the signal to turn off water.

Duties of Surgeon's Division.—The surgeon's division will prepare to remove sick and to treat injured. A medical officer and one hospital corpsman will report at the scene of the fire equipped to treat and transport personnel casualties. The remaining Medical Department personnel will report to their battle stations.

Collision.

Alarms.—

1. One long blast on the siren.
2. Word passed over loudspeakers, giving frame number and side of ship.

3. General alarm.
4. Collision quarters on the bugle.

In a collision of some magnitude, the personnel of the battle dressing station most convenient will report, if required, at the scene of the collision to render first aid and to transport the injured, thus augmenting the damage-control party. The personnel of all battle dressing stations will prepare for the reception and care of the injured.

Fire and Rescue Party.

The fire and rescue party may be called upon to assist a vessel on fire or otherwise in distress and to rescue personnel therefrom, or to render assistance on shore.

Alarms.—

1. General alarm.
2. By boatswain pipes and loudspeakers:
   (*a*). "Away fire, salvage, and rescue party."
   (*b*) "Away fire party."
   (*c*) "Away rescue party."
   (*d*) "Away salvage party."
3. Boat calls on bugle followed by "Double time."
4. "Assembly" on bugle followed by "Double time."

A junior medical officer and one hospital corpsman with one large hospital corps pouch and one Stokes stretcher will attend.

Abandon Ship.

Abandon ship may become necessary following serious underwater damage caused by collision, stranding, explosion, or damage sustained in battle. The above

conditions will generally find the crew at collision quarters or battle stations.

This bill provides for abandoning ship under two conditions:

A. Rapid sinking—No time to lower boats. Life rafts launched where possible.

B. Slow sinking—All boats and life rafts made available.

General instructions.—

1. The general alarm will be sounded, followed by a number of blasts on the alarm to indicate conditions A or B.
2. The "condition" will, if possible, be announced over all loud speakers.
3. Life preservers will be worn by all hands for either condition.
4. All officers will wear loaded pistols for condition B.
5. The report "Ready to abandon ship" will be made as indicated hereinafter.
6. No one will either embark in boats or life rafts or jump overboard until so ordered by the commanding officer.
7. If any boat or life raft to which personnel are assigned is unavailable, the personnel so assigned will stand-by to abandon ship as ordered by the commanding officer.
8. The sick and injured, provided with life jackets, will be taken to the port quarterdeck to assigned boats or life rafts. All Medical Department personnel, except those otherwise assigned, will assist in debarking patients.

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Sick and injured are given priority in abandoning ship.

9. Men so detailed by the medical officer will salvage valuable records.

Signals and variations in each condition.—

Condition A.—Word passed: "All hands abandon ship, condition A", and when directed by the commanding officer, "All hands overboard."

All hands will jump overboard and swim clear of the ship as quickly as possible to avoid suction and may later return to life rafts or floating equipment. Sick and injured will be assisted over the side and away from the ship by all available personnel.

Condition B.—Word passed: "All hands abandon ship, condition B"; "Away all boats and life rafts."

Sick and injured will be evacuated by the surgeon's division to the abandon-ship station designated for that purpose and debarked therefrom when directed. Personnel of the division not required to accompany sick and injured will report to their abandon-ship stations.

MAN OVERBOARD.

Alarms.—

1. General alarm.
2. Word passed over loud speakers.

Duties of surgeon's division.—A medical officer will stand-by on the bridge to render such assistance as may be required. A hospital corpsman with first-aid pouch will proceed "on the double" to the lifeboat to be lowered.

Chapter XI

THE MEDICAL DEPARTMENT ON BOARD SHIP IN BATTLE

Our experiences in modern warfare have necessitated marked changes in the medical preparations for battle aboard all types of ships. This has been incidental to new weapons and improved methods of attack; both being factors of increased exposure of personnel manning details which are without full benefit of armor protection.

Our previous concepts that both medical personnel and material should be behind armor during battle must be abandoned to a large extent. Stringent rules against the opening of watertight doors in enemy areas make battle dressing stations below protective decks inaccessible, therefore their number must be reduced to a minimum, and be classified as "reserve" stations rather than "active" ones. Bombs and torpedoes have reduced the element of protection to a relative degree only. Means of assistance must be organized roughly on the system of land warfare, in that our trenches start on the weather decks and proceed downward to the lowest deck occupied by the personnel.

It is necessary to bring first aid to casualties by all available means possible; expeditiously, efficiently, and adequately. Expeditious emergency treatment to casualties where found obviates their descent en masse,

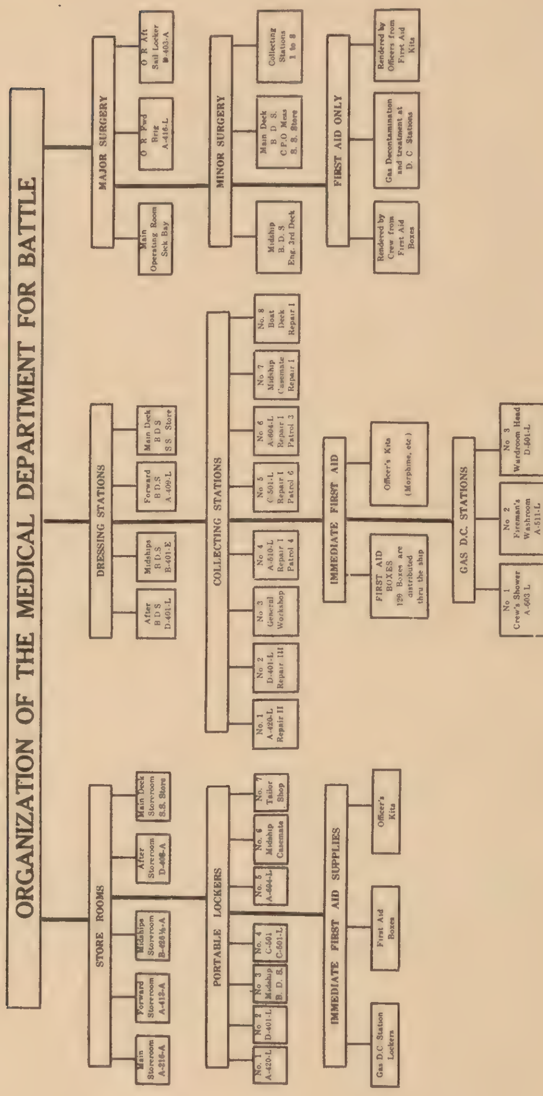

ORGANIZATION OF THE MEDICAL DEPARTMENT FOR BATTLE
STORE ROOMS
Main Storeroom A-216-A
Forward Storeroom A-412-A
Midships Storeroom B-426½-A
After Storeroom
Main Deck Storeroom S.S. Store
PORTABLE LOCKERS
No. 1 A-420-L
No. 2 D-401-L
No. 3 Midship B. D. S.
No. 4 C-501 C-501-L
No. 5 A-604-L
No. 6 Midship Casemate
No. 7 Tailor Shop
IMMEDIATE FIRST AID SUPPLIES
Gas D.C Station Lockers
First Aid Boxes
Officer's Kits
DRESSING STATIONS
After B D S D-401-L
Midships B D S B-401-E
Forward B D S A-409-L
Main Deck B D S S S Store
COLLECTING STATIONS
No. 1 A-420-L Repair II
No 2 D-401-L Repair III
No 3 General Workshop
No 4 A-510-L Repair I Patrol 4
No 5 C-501-L Repair I Patrol 6
No 6 A-604-L Repair I Patrol 3
No 7 Midship Casemate Repair I
No. 8 Boat Deck Repair I
IMMEDIATE FIRST AID
FIRST AID BOXES 129 Boxes are distributed thru the ship
Officer's Kits (Morphine, etc.)
GAS D.C. STATIONS
No 1 Crew's Shower A-603 L
No 2 Fireman's Washroom A-511-L
No 3 Wardroom Head D-501-L
MAJOR SURGERY
Main Operating Room Sick Bay
O R Fwd Brig A-416-L
O R Aft Sail Locker B-403-A
MINOR SURGERY
Midship B. D. S Eng. 3rd Deck
Main Deck B D S. C.P.O Mess S. S. Store
Collecting Stations 1 to 8
FIRST AID ONLY
Rendered by Crew from First Aid Boxes
Gas Decontamination and treatment at D. C Stations
Rendered by Officers from First Aid Kits

FIGURE 17.

with assisting shipmates, upon the dressing stations, tending to cause confusion, disruption of orderly assistance, near panic and hysteria. These considerations, secondarily to humanitarianism, justify our system of taking first aid to the wounded rapidly. The ship's "watertight integrity" must not be violated, nor the "volume of fire" decreased in this process.

The prime requisite for an efficient organization is *dispersion* of both *personnel* and *material* throughout the ship at *all* times. This permits availability to as many persons as possible and despite contingencies incidental to the ship's damage. *Decentralization* cannot be overemphasized. Its accomplishment can only be attained by thorough study of each ship's compartmentation, availability of utilities, easy accessibility for the greatest number in each area, and facilities for storage of supplies at the site. The structural variations existing in the different types of ships preclude a standard plan, but all organizations should essentially possess the following characteristics which are adaptable to a battleship. Modifications to suit type and size of ship must be selected.

Battle Dressing Stations.

Equipment.—This must be adequate to perform surgery and major dressings. It should include instruments, dressings, drugs, intravenous solutions, plasma, and anesthetics of local, intravenous, and spinal varieties. The location must furnish lighting systems of both emergency and normal types, power sockets for sterilizers and water heaters, water from ship's system and from emergency tanks or portable containers. Emergency toilet facilities, portable storage battery

lights, canned foods, folding dressing tables, lockers, and operating table of the folding variety, or its equivalent, are needed. Additional equipment such as buckets with sand, fire extinguishers, and swabs are necessary.

The stations should be located where they can afford aid to the greatest number, be accessible and with whatever protection is compatible with their function. One,

FIGURE 18.—Emergency battle dressing locker (Pomeroy).

by all means, must be accessible with a minimum of effort to weather deck and casemate personnel.

BATTLE LOCKERS.

These consist of portable metal lockers as suggested in figure 18.

Contents, battle dressing locker (Pomeroy)

Acid, tannic, ½ pound bottle	4
Alcohol, ethyl, ½ gallon tin	1
Applicators, bundle	1
Assorted sutures and needles	assorted
Bag, hot water, rubber	1
Bandage, gauze, 1-inch, dozen	1
Bandage, gauze, 2-inch, dozen	3
Bandage gauze, 3-inch, dozen	2
Bandage, muslin, 4-inch	4
Battle dressings, large	20
Battle dressings, small	40
Blankets	1
Blood plasma, 250-cc. units	6
Boric acid, in gallon jug, to make a saturated solution	1
Case, forceps, hemostatic	1
Case, pins, scissors and dressing forceps	1
Case, pocket	1
Castor oil, 2-ounce bottle and medicine dropper	1
Cotton, 1-pound roll	1
Dextrose, 5 percent normal saline (vacoliters)	6
Dressings, sterile, (4 by 4) 25 in package	4
Dressings, sterile, (2 by 2) 25 in package	4
Flashlight	1
Flask, Erlenmeyer, 125-cc. (sterile)	2
Flit gun	1
Gauze, plain, 25-yard roll	3
Gentian violet, powdered, 10-gm. bottle	1
Gloves, rubber, sterile, pair	2
Jelly of tannic acid, 8-ounce tubes	12
Medicine glasses, (sterile)	2
Morphine Syrettes	40
Pencil, lead	1
Pencil, wax, red (skin pencil)	1
Petrolatum, liquid, 1-quart tin	1
Plaster, adhesive, roll (2 inches by 5 yards)	5
Procaine hydrochloride, 0.0740-gm. 100 bottles	1
Shipping tags	36

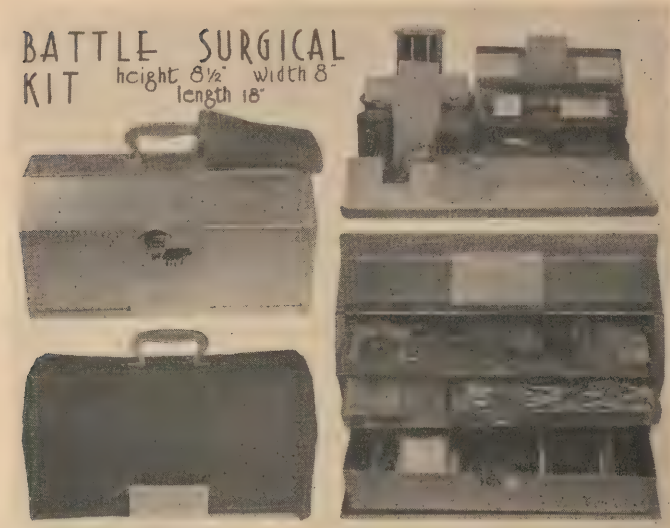


FIGURE 19.—Portable instrument kit (Allen).

Contents, battle dressing locker (Pomeroy)—Continued

Soap solution, 16-ounce bottle	1
Splints, basswood	6
Sulfanilamide, powdered, ¼-pound bottle	4
Syringe, glass, 10-cc. sterile needle	2
Syringe, glass, 5-cc. sterile needle	1
Syringe, glass, 2-cc. sterile needle	2
Tablespoons (for retractors)	2
Test tube, with 3-inch needles	1
Tincture merthiolate, 16-ounce bottle	2
Tincture green soap, 16-ounce bottle	1
Tongue depressors, bundle	1
Tourniquet, instant, rubber	12
Towels, sterile	6
Water, distilled, 10-cc. vial	6

The recommended minimum of portable lockers is 10 for battleships and aircraft carriers, 5 for cruisers, 2

for destroyers, and proportionate numbers for ships of other types. Their contents must be sufficiently complete to outfit an emergency aid or casualty collecting station, or to take care of any fairly large group of wounded cases in an isolated area.

Their distribution must be in strategic compartments throughout the ship, and independent of the battle dressing stations.

A portable instrument kit, (Allen) such as illustrated in figure 19, has many excellent features. It is made of scrap plane metal, and allows of sterilization by complete immersion or autoclaving.

Boxes—First-Aid.

These should be the "1-cubic-foot" or "breadbox" variety for installation as subdressing stations wherever 20 or 30 men are on duty. They should contain practical first-aid materials, be portable, clearly marked with a red cross, and wire sealed for easy access. These boxes should contain morphine Syrettes at all times. A minimum of 100 in each battleship is indicated.

Gun Bags.

These should be made of canvas and attached in the immediate vicinity of all guns for use by gun crews. Contents consist of:

(*a*) Cotton, for ears.
(*b*) Tourniquet, rubber, instant.
(*c*) Small dressings.
(*d*) Bandages.
(*e*) Tannic acid jelly (tube).

Gas-Decontamination Lockers.

These are metal lockers with hinged table top as suggested in figure 20.

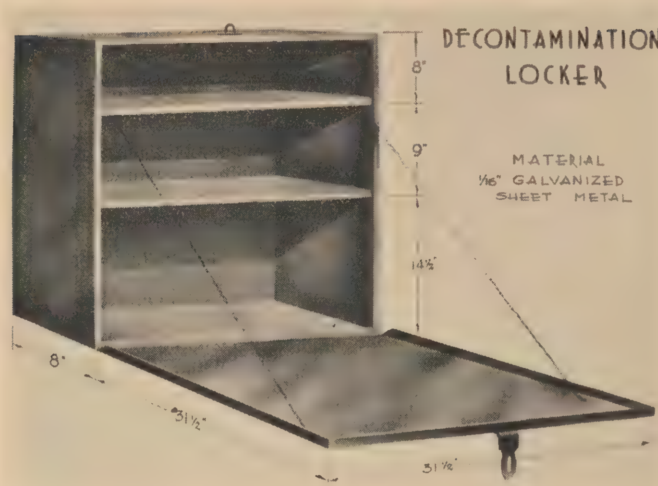


FIGURE 20.—Gas-decontamination locker (Maher).

Contents, gas-decontamination locker (Maher)

Adhesive plaster, 2-inch by 5-yard rolls	2
Alcohol, ethyl, 95 percent, pint bottle	2
Applicators, bundle	1
Bandage, gauze, 2-inch, dozen	1
Bandage, gauze, 3-inch, dozen	1
Bleach paste, gallon	1
Boots, rubber, pair	1
Boric acid, 208-gm. in gallon bottle	1
Brushes, nail	6
Buckets	2
Carbon tetrachloride, gallon	1
Cotton, absorbent, 1-pound roll	1
Clothing, impregnated, suit	1
Cupric sulfate, 2-ounce bottle	1
Dressings, battle, small	24
Dressings, battle, large	3
Dressings, gauze, 6 by 8's	24

Contents, gas-decontamination locker (*Maher*)—Continued

Dressings, gauze, 2 by 2's	48
Ferric hydrate paste, tin pail for	1
Ferric sulfate solution, pint	1
Gauze, plain, 25-yard roll	2
Gloves, rubber, size 8, pair	6
Irrigating can, ready for use	1
Milk of magnesia, pint	3
Mineral oil, with dropper, 100 cc	1
Petrolatum, white, can	4
Rags, cleaning, bundle	2
Salt water soap, bar	3
Sodium bicarbonate, 75 gm. in gallon bottle	1
Sodium hydroxide, 24 gm. in bottle	1
Spoon, large	1
Tannic acid jelly, tube	10
Tincture green soap, gallon	1
Tincture iodine, 3½ percent, 200-cc. bottle	1
Tongue depressors	24

Site of installation should be chosen for availability of running water, and its adaptation for rapid segregation of contaminated and decontaminated cases.

CASUALTY COLLECTING STATIONS.

They should be selected in accordance with size, accessibility, and their regularly installed facilities and utilities. These spaces will be for the collection and classification of the wounded before receiving further treatment at the battle dressing station.

BURN LOCKERS.

These can be made portable and stowed in previously designated compartments, with the idea of utilizing them as far as practicable for the reception, segregation, and emergency treatment of burn cases.

Main Storeroom.

This is situated in the compartment designated on the ship's plans. It will contain the excess medical stores for replenishment of the previously mentioned sources throughout the ship. A small "issue" space may be used as a subsidiary to the main storeroom.

Boat Box.

The following is a list of the contents of the Navy boat box, a fixture in all boats used in abandoning ship:

Jelly of tannic acid, tube	12
Morphine Syrettes	10
Petrolatum, liquid, quart	2
Spirit of ammonia, aromatic, tube and paper cup	4
Acid, acetylsalicylic, 0.324 gm., 100	1
Extract of cascara sagrada, 100	1
Soda mint tablets, 0.324 gm., 100	1
Tincture of iodine, mild, 10-cc. applicator vial	3
Bandage compress, 2-inch	8
Bandage compress, 4-inch	1
Bandage, gauze, compressed, 1-inch	6
Bandage, gauze, compressed, 2-inch	6
Bandage, gauze, compressed, 3-inch	6
Bandage, triangular, compressed	2
Cotton, absorbent, compressed	4
Gauze, plain, compressed	6
Pins, safety, large	12
Splint, wire mesh for, 5 x 36 inches	1
Tourniquet, web	1
Sulfadiazine, 24 1-gram tablets in package	2
Sulfanilamide, powdered (for topical application), 5-gram packet	25

Raft Kit.

The understandable limitations of space aboard a life raft necessitate the following compactness:

Jelly of tannic acid, ¾-ounce tube	2
Bandage compress, 4-inch	2
Morphine Syrettes, 5 tubes; and tincture of iodine, mild, 10-cc. applicator vial, 1 vial in package	1
Sulfadiazine, 24 1-gram tablets in package	1
Sulfanilamide, powdered (for topical application), 5-gm. packet	5

Medical Personnel

Distribution.—Medical and dental officers are assigned to each of the battle dressing stations. Hospital corpsmen are distributed as follows:

(1) Battle dressing stations.
(2) Repair parties.
(3) As patrols on weather decks.
(4) Decontamination stations.
(5) Stretcher bearers (from crew).

It is preferable that they be billeted near their stations for increased decentralization and for availability at all times. Each corpsman must wear a basic equipment which is supplemented for those having topside patrols or with repair parties.

Basic equipment.—Applicable to the medical complement as a whole.

(1) Hospital Corps pouch (large), with substitution of contents to suit wartime conditions.
(2) Flashlight, hand, with suitable lanyard to avoid loss at all times.
(3) Scissors, bandage—with lanyard.
(4) Gas mask.
(5) Life jacket.

Special equipment.—For corpsmen detailed to repair parties or as roving patrols on weather decks. Emer-

gency kits or instrument carriers of a type similar to the following illustrations in figures 21, 22, and 23. Their

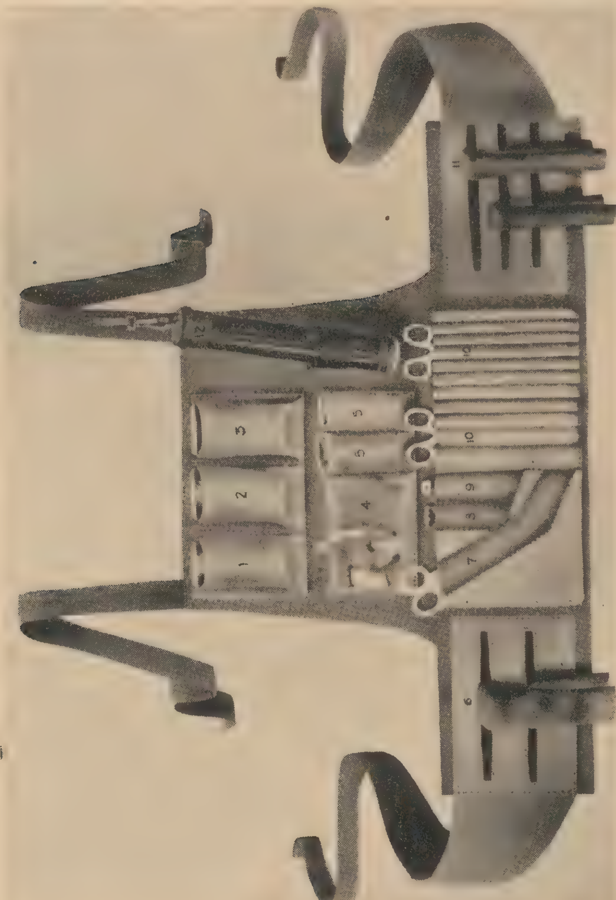


FIGURE 21.—Handy instrument carrier (Broaddus).

purpose is to increase supplies for immediate use, but they must not be sufficiently bulky to interfere with

locomotion, or with passage in narrow openings, or in damaged spaces.

Contents of instrument carrier (Broaddus)

Pocket No.	*Item*
1, 2, 3.	Morphine Syrettes.
4.	Adhesive tape, on reel.
5.	Tannic acid jelly.
6.	Flag bunting (green) or suitable means to indicate that morphine has been given.
7.	Bandage shears.
8.	Ophthalmic ointment.
9.	Jackknife.
10.	Hemostats.
11.	Tourniquets.
12.	Flashlight.

Stretcher bearers—are an important adjunct to the rendering of aid to the injured. These men should be detailed systematically, especially instructed for rendering medical assistance, and have a complete knowledge of available medical facilities and their location. The number of stretchers aboard is roughly 3 to 4 percent of complement, and consists of the Stokes, the Army litter, and "zipper" or "hammock" varieties. The number will vary with the type of ship.

The organization should be made *flexible* in every sense, both as to personnel and material. The members should be regularly instructed in their battle duties, rotated periodically in the various details to allow familiarization with all spaces aboard ship, and thoroughly taught routine treatments for the more common casualties. In this respect attention is called to *burns* which usually predominate in naval combats. It is desirable to select one recognized simple method

of treatment for each ship; this avoids confusion and delay.

FIGURE 22.—Carry-all for first-aid supplies (Marron).

The entire ship's complement must be instructed in first aid, a highly essential feature, repeatedly demon-

FIGURE 23.—Carry-all for first-aid supplies (Morrison).

strated as a lifesaver in all battles of this war. Stretcher bearers will require special instructions for their duties.

The organization must be sufficiently flexible to permit rapid appropriation of improvised spaces for maximum assistance where casualties are found. By that token, the need exists for readily obtainable supplies in adequate quantities. Some special items are essential, such as morphine Syrettes in all dispersal sources, intravenous and spinal anesthetics, intravenous solutions—glucose and saline, dry blood plasma at all battle dressing stations, splints, plaster of paris, burn remedies, and large quantities of eye lotions.

Portable drinking fountains of suitable types are needed to quench the extreme thirsts noted in battle. Ship's water supply lines are often broken in action.

The possible rupture of electric cables will require hand battery flashlights for each individual at all times. Thongs or lanyards are indispensable to prevent their loss as a result of sudden blows, concussions, and falls. Magazine or battery lamps for the operating tables should be furnished at the battle dressing stations. Failure of the lighting systems aboard a warship furnishes a terrible handicap, especially if accompanied by smoke or explosion gases, and damage caused by shells, bombs, or torpedoes.

Sterilization of instruments by means other than steam should be available.

Glassware, reduced to a minimum, should be protected by use of scotch tape, or its equivalent, to prevent shattering by gunfire or explosions.

Chapter XII

TRANSPORTATION OF THE SICK AND INJURED ON BOARD SHIP

Transportation of the sick and injured aboard ship presents problems influenced by type of injury, condition of patient and his location aboard said ship. There are many compartments and spaces only accessible by means of scuttles, small hatches, manholes, and tortuous and narrow passageways. Some spaces are further restricted by stanchions, machinery, boilers, and lockers to a degree which presents a complicated problem of transportation to the stretcher bearer.

Necessity and ingenuity have combined to solve these by primitive manhandling, and by mechanical devices designed so far as possible for the painless, harmless extraction and transportation of casualties.

"Manhandling" or hand carry should be performed carefully to avoid further injury, and can be fairly safely performed by two or more volunteers.

The unconscious patient, with complicating fractures of extremities or back, will require careful assistance by means of mechanical appliances such as the following:

(1) Stokes stretcher, or some of its modifications.
(2) Pole stretcher.
(3) Army litter.
(4) Weber "zipper" stretcher.

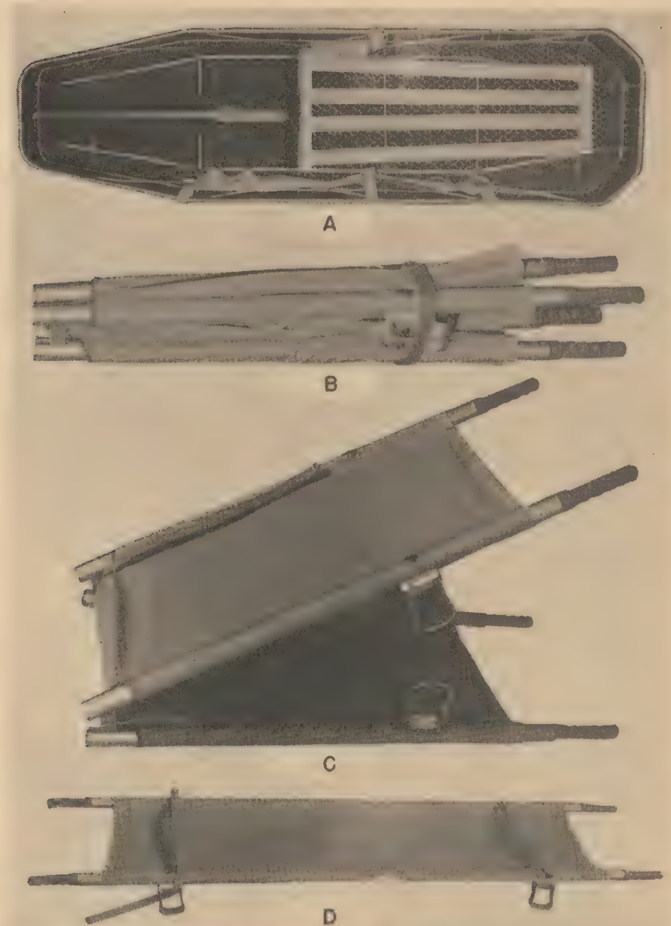


FIGURE 24.—A.—Stokes splint stretcher. B and C.—Pole litter, folding. D.—Same, nonfolding.

(5) Hammock stretcher (Farrar).
(6) Canvas "zipper" litter (Davis).
(7) Neil Robertson (British).
(8) Totsuka (Japanese).
(9) Hammock type (German).

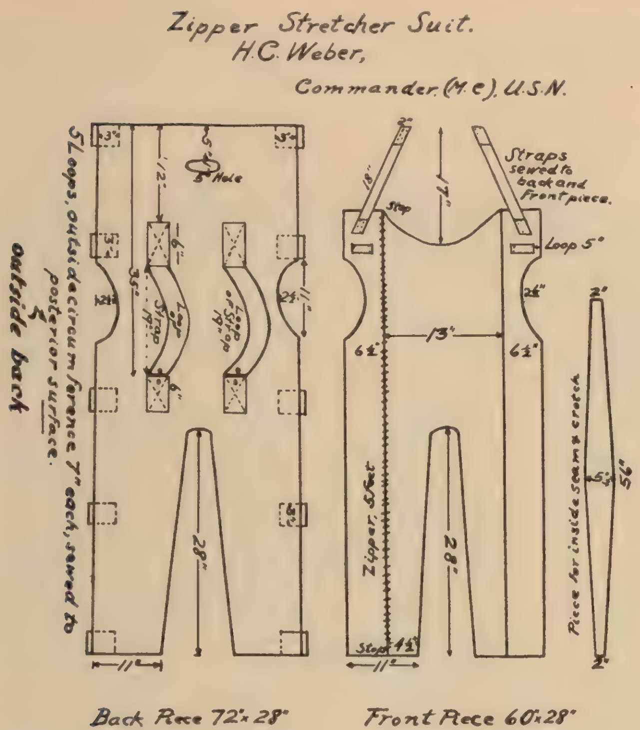
and several other ingenious modifications adequately fulfilling the purpose.

The most commonly used is the Stokes splint stretcher (fig. 24–A). This stretcher is a galvanized iron or aluminum stretcher basket so constructed that immobilization of body and lower extremities is possible, thereby allowing a thoroughly secured patient to be hoisted in an upright position through hatches and manholes if necessary, or permit of transfers from ship to ship at sea by means of any suitable hoisting apparatus available. The disadvantages are its rigidity and width when used in complicated spaces, such as escape hatches, narrow tortuous passageways, turrets, handling rooms, and machinery spaces. It is an excellent, safe, comfortable means of transportation. Some modifications have improved the original design by slightly changing its shape, decreasing weight, and by articulation in its middle for better storage. It is provided with hand grips for hand carry or for attaching a bridle for hoisting. A septum separates the legs, which can be secured for immobilization. Adjustable foot rests permit the body weight to be carried by one or both legs in the upright position. Canvas straps are used to retain the patient firmly in position. These straps should always be attached, rolled neatly and simply to allow rapid securing of patient.

The Army-type litter (fig. 24) and its counterpart as improved, articulated, and made much lighter for field and shipboard use, is also available. It can be used

Figure 25.—Modified "gas-pipe" stretcher (King).

only when no difficulties of transportation are present and when the patient will not be exposed to the possibility of falling. These can be employed as temporary beds when a major casualty has exhausted the



The front of the suit consists of three pieces of canvas, two side, and one center. The side pieces are identical, 60 by 6 or 7 inches The lower edge is straight. The upper edges form a downward curve with the centerpiece as illustrated to allow room for the neck. The center piece of the front is 13 by 55 inches, a little longer at the outer edges to meet the line from the side pieces. The lower part is cut out to conform to the dimensions of the back piece canvas of the legs. To give extra room in the crotch, a piece of canvas, 5 inches at the widest portion—i. e., the crotch—and gradually tapering off to 2 inches, is sewed between the front and back piece of the legs. See drawing. To the inside of the crotch is sewed a pad of hair-felt horizontally, dimensions 10 by 6 by 2 inches.

FIGURE 26.—Weber zipper stretcher.

usual facilities. Hence 20 or 25 of these should be in each battleship with a proportionate number in smaller crafts.

The removal of injured or sick from areas difficult of access is accomplished by the use of flexible appa-

FIGURE 27.—Hammock stretcher (Farrar).

ratus, with or without some immobilizing features, and usually made of canvas. One of these is the Weber "zipper" stretcher or "zipper stretcher suit" (fig. 26).[1] The procurement of zippers may be difficult, due to priorities, in which case grommets and white-line lacing

[1] Original description appeared in U. S. Naval Medical Bulletin, July 1936.

may be substituted. The effects of salt air, weather, and encroaching clothing may cause failure of zippers to function.

A simple, easily made canvas "hammock stretcher" is illustrated. Hammocks are always available aboard ships, and the stretcher may be easily folded for storage at strategic spots. Its method of use is shown in figure 27.

Another simple canvas appliance having many uses is shown in figure 28.

The Germans use an ordinary hammock (fig. 29–C) with beckets placed at the outer quarters to allow some overlapping for security; three beckets on each side, two near the head, and canvas straps securing patient by crossing at perineum.

The Neil Robertson stretcher (fig. 29–B) used by the British is light, serviceable, made of canvas, and reinforced by bamboo. It allows splinting for carrying, may be suspended vertically and hung as a hammock. The Japanese Totsuka stretcher (fig. 29–A) is fairly similar in construction. All canvas appliances are strictly for shipboard use unless they are further equipped with loops for the introduction of poles which convert them into rigid stretchers. A tendency is to employ heavier canvas than needed, and to overlook the necessity of a rope attached at all times for assistance in lifting from lower decks or lowering from fighting tops.

Transportation of sick and injured involves transfers at sea from one ship to another, or rescues of survivors from the ocean. Smaller ships such as destroyers are preferable for use because of their speed and low freeboard. Cargo nets may be thrown over the side, thereby making it possible for survivors, not severely injured,

to climb aboard. Much assistance can be rendered by the ship's company in this manner.

FIGURE 28.—Simple canvas stretcher (Davis)

A member of the Medical Department will assist greatly by classifying and distributing the casualties as they come over the side. This will prevent confusion

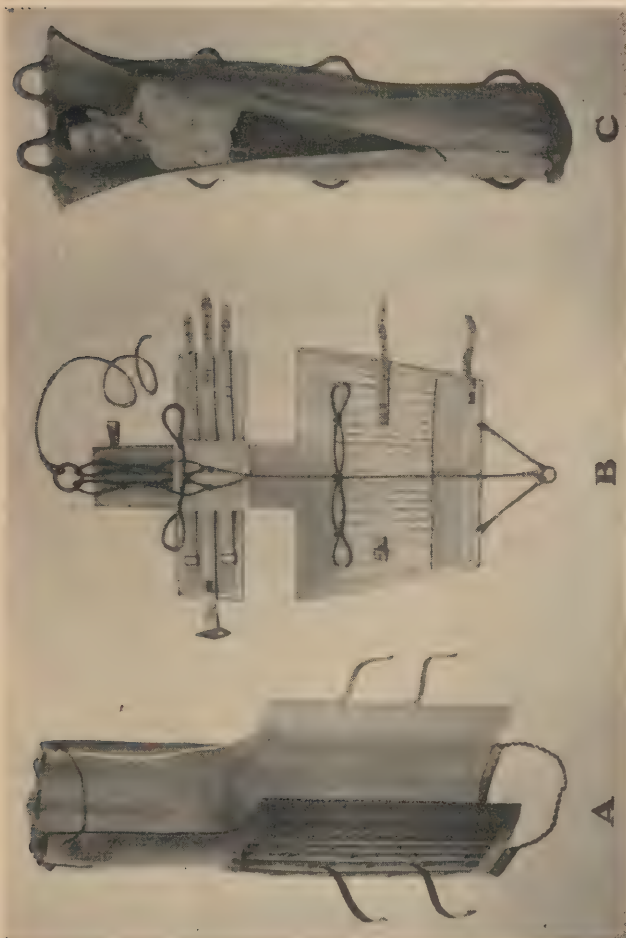


FIGURE 29.—A—Totsuka stretcher. B—Neil Robertson stretcher. C—German hammock type.

FIGURE 30. Litter lifting rods (Broaddus).

and unnecessary crowding in the sickbay or in spaces previously prepared for the reception of specific types of injuries.

Should there be many severely injured cases, these can be expeditiously handled from ship to ship by means of appliances quickly improvised by the rescuing ship. One of these is the construction of a platform with raised edges, and suspended from slings. It is preferably made to carry three stretchers at a time, and equipped with securing lines for lashing which will afford additional protection against sliding. The edges of the platform must be sufficiently high to equal the depth of a Stokes stretcher.

A breeches buoy may be used for transfer of slightly wounded from ship to ship if, for military reasons, it is necessary to do this underway.

Two- or three-litter-capacity lifting rods consisting of two 1¼-inch galvanized pipes, the ends of which have been flattened and drilled with a ½-inch hole, may be used as in figure 30. The poles (pipes) are 51 inches for the two-litter lift, and 73 inches for the three-, and are passed through the legs of Army type stretchers. Patients on Army litters must be thoroughly secured to prevent their falling. This is accomplished by the use of canvas straps, bunk straps, or single-ply canvas, 12 inches by 72 inches, cut to form three-tailed ends 16 inches long, and tapering to 2 or 3 inches wide at the ends. These are passed under the stretcher and the three opposing ends are tied across the patient's abdomen.

Chapter XIII

FUNDAMENTALS OF ACCIDENT PREVENTION ABOARD SHIP

Both a physical hazard and faulty human behavior are necessary for an accident to happen. Full attention must be given to both. We must use every means of eliminating or reducing the physical hazard, and in addition do everything possible to control the human behavior.

Wherever accident frequency and severity are kept under control, the fundamental principles of scientific accident prevention must exist. These are: The creation and maintenance of active interest in safety; periodical inspections of machines, tools, equipment, processes, and work procedures; accident investigation for the determination of causal facts; and corrective action based on these facts.

The creation and maintenance of active interest in safety as a first principle of accident prevention must apply to officers as well as to the men.

From the standpoint of the first lieutenant, the medical officer, and division officers, a job of salesmanship is necessary. To arouse and maintain the interest of a person it is necessary to appeal to one or more of his stronger senses or desires such as: Self preservation—appeal to the individual's fear of personal injury; desire for personal gain or reward; loyalty to one's commanding officer, division officer, and to shipmates; sense of responsibility to one's job, division, shipmates, and to ship.

Pride in one's work, in one's division, and in one's ship is one of the strongest incentives a man can have for producing the best work within his ability. Approval of good work is a successful medium of approach because it is human nature to appreciate recognition. The pride of living up to a standard, rivalry, the comparison with good practice, a desire for leadership or promotion are all forceful and compelling factors. Logic and a sense of humanity can be inculcated; arouse humanitarian instincts by giving first-aid courses.

A health and safety program should be organized on every ship, and safety committees appointed in each division to assist the first lieutenant and medical officer with the program. Frequent talks should be given to the men on the subject accident prevention and its importance. Posters, pamphlets, slides, motion pictures, and articles in ships' papers should be utilized.

Periodical inspections to locate and identify physical hazards are exceedingly important. The following list of basic items that should be looked into is used by a safety engineer of long experience:

Housekeeping, which includes inspection for loose material and objects underfoot or overhead, method of piling, projecting nails, disposal of scrap and waste, grease, water or oil spillage, and tool maintenance.

Material and store handling methods.

Guarding of transmission machinery.

Point of operation guards.

Decks, ladders, railings.

Cranes, hoists and derricks.

Lighting.

Electrical equipment, particularly extension cords.

Eye protection from harmful light, rays, heat or glare, flying objects, splashes of corrosive substances, etc.

Other personal protective equipment: In certain types of work men need respirators, life lines, life jackets, safety shoes, special gloves and other protective clothing.

Dusts, fumes, gases, vapors.

Ventilation of storerooms and confined spaces.

Pressure vessels.

Any other fire and explosion hazards, as volatiles, gases, chemicals.

Other dangerous substances.

Inspection of chains, cables, slings, etc.

Access to overhead valves, equipment, etc.

The above list is limited almost wholly to physical hazards because the discovery and correction of unsafe working practices requires continuous watchfulness and painstaking training and education.

Every disabling accident aboard ship should be investigated immediately for "cause analysis" and not for the sole purpose of fixing blame. All minor accidental injuries and as many near-injury occurrences as possible should also be investigated. Continuous analysis of operations and jobs to discover and permit the correction of hazardous conditions should be maintained. The purpose of accident investigation is to find hazardous conditions and practices that can be corrected so as to prevent the recurrence of similar accidents.

Principles of accident investigation that should be followed to secure maximum results include the use of common sense and clear thinking in collecting facts, weighing the value of each, and reaching conclusions justified by the evidence. Sufficient familiarity with the equipment, operation, or process to permit an understanding of possible hazards that may exist, is essential. Each clue and factor, even when apparently of little

importance, should be fully investigated. Since a physical hazard and faulty human behavior are both present in the majority of accidents, both must be considered fully. After an accident investigation if a definite recommendation for corrective action is not made then the investigation was not satisfactory. Immediate investigation of all accidents is necessary because conditions may change quickly and details be forgotten.

Corrective action should be based on available and pertinent facts and may include a consideration of any of the following:

1. Personal:
   - *a.* Instruction, enforcement of instruction or education.
   - *b.* Protective equipment and devices, such as respirators, goggles, life lines, and protective clothing.
   - *c.* Prevention or at least reduction of amount of exposure to hazards.
2. Medical:
   - *a.* Periodical physical examination.
   - *b.* Salt intake for prevention of heat reactions.
3. Mechanical:
   - *a.* Ventilation, general or local exhaust.
   - *b.* Change, enclose, or isolate harmful processes.
   - *c.* Substitute less toxic for toxic material.
   - *d.* Adequate guarding of all moving parts of machinery likely to injure someone.
   - *e.* Adequate natural or artificial lighting according to the type of work or operation being performed.
   - *f.* Revise any operation that can be done in another, safer, and better manner.

The Navy proceeds with the belief that dangerous material can be handled safely and that any mechanical job can be performed safely if proper study is given in advance and the necessary precautions observed.

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CHAPTER XIV

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Actinomycosis	1. Recognition by clinical manifestations confirmed if possible by microscopic examination of discharges from lesions. 2. Isolation: None.	1. Quarantine: None. 2. Immunization: None. 3. Instruction regarding oral hygiene.	1. Concurrent disinfection of lesions and articles soiled therewith. 2. Terminal disinfection by thorough cleaning. 3. Check possibilities of exposure to infected cattle or use of infected milk.
Angina, Vincent's (stomatitis, Vincent's), (gingivitis, Vincent's).	1. Recognition on clinical manifestations with or without bacteriological confirmation. 2. Isolation: None. 3. Correction of abnormal or diseased conditions of gums and teeth. 4. Instruction in regard to diet (particularly in reference to vitamin C), gum massage, use of dental floss, and the tooth brush.	1. Inspection of mouth and throat. 2. Correction of abnormal or diseased conditions of gums and teeth. 3. Instruction in regard to diet (particularly in reference to vitamin C), gum massage, use of dental floss and the tooth brush. 4. Quarantine: None. 5. Immunization: None.	1. Check on efficacy of dish-washing facilities. 2. Check against possible use of common drinking cup. 3. Concurrent disinfection: All discharges from nose and throat. 4. Terminal disinfection: None.
Anthrax	1. Recognition by clinical and (if possible) bacteriological means. 2. Isolation: Until the lesions have healed.	1. Check possible contact with infected hides, wool, hair, bristles. 2. Quarantine: None. 3. Immunization: None.	1. Concurrent disinfection of discharges from lesions (spores can be killed only by such measures as burning or steam under pressure). 2. Terminal disinfection: Thorough cleaning. 3. Search for the source of infection (hides, wool, hair, bristles of infected animal).

Ascariasis	1. Recognition by identification of ova lumbricoides, ascaris, in stools. 2. Isolation: None. 3. Suitable treatment with appropriate agent such as hexylresorcinol, and of chenopodium or santonin should reduce the communicability of the disease.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: Sanitary disposal of feces and washing hands in soap and water after defecating and before eating. 2. Terminal disinfection: None.
Catarrhal fever including: Bronchitis, acute; common cold; laryngitis, acute; pharyngitis, acute; rhinitis, acute; tracheitis, acute; tracheobronchitis, acute.	1. Recognition on clinical mani festations. 2. Isolation: During febrile period.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection of the discharges from the nose and throat or articles soiled therewith.
Cerebrospinal fever (meningitis, meningococcus).	1. Recognition on clinical manifestations, confirmed if possible by microscopic and bacteriological examination of spinal fluid as well as bacteriological examination of nasal and pharyngeal secretions. 2. Isolation: Until 14 days after onset of the disease or until negative swabs are obtained from the nasopharynx. 3. Prompt treatment with an appropriate chemotherapeutic agent such as sulfadiazine or sulfanilamide should be useful in limiting communicability.	1. Quarantine: None. 2. Advise contacts to avoid as far as possible for 10 days excessive chilling, bodily fatigue, physical strain. 3. Observation of nonimmune contacts daily for 10 days following last date of contact unless bacteriological studies of nasal and pharyngeal secretions negative. 4. Prophylactic use of an appropriate chemotherapeutic agent such as sulfadiazine or sulfanilamide in the close contacts may be helpful. 5. Immunization: None.	1. Concurrent disinfection of the discharges from the nose and throat or articles soiled therewith. 2. Terminal disinfection: Cleaning. 3. Increase separation of individuals and discourage crowding. 4. Improve ventilation of living and sleeping quarters.

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Chancroid including: chancroidal lymphadenitis.	1. Recognition by clinical manifestations and exclusion of syphilis and lymphogranuloma venereum ((a) Withhold local medication until 3 negative dark-field examinations, carried out on successive days, have been obtained; (b) do Frei test for lymphogranuloma venereum if possible; (c) do a blood serologic test for syphilis and repeat every month for 6 months after healing of lesions.) 2. Isolation: Place on "venereal restricted list" and refuse all shore leave until lesions heal. 3. Education: Stressing (a) that continence is compatible with health and normal development; (b) that prophylaxis is available and advisable if self-control has failed and promiscuous sexual intercourse has occurred. 4. Proper treatment with saline dressings alone the first 3 days followed by appropriate chemotherapeutic agents such as sulfanilamide locally and sulfathiazole or sulfadiazine systemically should render a patient noninfective in 14 days in most instances.	1. Quarantine: None. 2. Immunization: None. 3. Search made for infected person from whom patient received infection. Report made to proper authorities to bring about control and treatment of this spreader.	1. Concurrent disinfection: Sanitary disposal of all dressings, disinfection of all articles soiled by discharges. 2. Terminal disinfection: None. 3. Check against common use of towels and toilet articles.

Chickenpox (varicella)	1. Recognition by clinical means only (be meticulous to eliminate the possibility of smallpox). 2. Isolation: From all nonimmune until all blebs are dried but not necessarily until all scabs are shed.	1. Quarantine: None 2. Immunization: Passive immunization, in exceptional cases only, of nonimmune contacts with intramuscular injection of 2 to 10 cc. of serum from a patient 4 to 6 weeks convalescent from chickenpox. 3. Observation every second day of all nonimmune contacts through period of 21 days. 4. No observation of contacts presumably immune.	1. Concurrent disinfection: Articles soiled by discharges from lesions. 2. Terminal disinfection: Thorough cleaning.
Cholera	1. Recognition by clinical symptoms confirmed if possible by bacteriological examination of stools. 2. Isolation: In sickbay or screened room for 7 to 14 days and until cholera vibrios are absent from bowel discharges.	1. Quarantine: Contacts for 5 days from last exposure, or longer if stools are found to contain the cholera vibrio. 2. Immunization: Prophylactic reimmunization of ship's personnel with 1 cc. "booster dose."	1. Concurrent disinfection: Prompt and thorough disinfection of stools and vomitus. Disinfection of articles used by or in contact with patient. Food left by the patient should be burned. 2. Terminal disinfection: Thorough cleaning of entire room and the contents. 3. Search for unreported cases or carriers. 4. Investigate water, milk, food—chlorinate all water, cook all food.
Coccidioidomycosis	1. Recognition on clinical manifestations confirmed by bacteriological examination if possible of the fresh discharges. 2. Isolation: None.	1. Quarantine: None. 2. Immunization: None. 3. Instruction regarding importance of obtaining prompt treatment of all skin wounds, even trivial ones.	1. Concurrent disinfection: All discharges from skin lesions or necrotic lymph nodes and all sputum and articles soiled therewith. 2. Terminal disinfection: Not important.

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Dengue	1. Recognition by clinical manifestations. 2. Isolation: In sickbay or screened quarters for 5 days.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: None. 2. Terminal disinfection: None. 3. Search for unreported or undiagnosed cases. 4. Measures to eliminate the *Aëdes aegypti* mosquito and its breeding places.
Diphtheria	1. Recognition by clinical symptoms with confirmation, if possible, by bacteriological examination of discharges. 2. Isolation: Until 2 cultures from the throat, and 2 from the nose, taken not less than 24 hours apart, fail to show the presence of diphtheria bacilli. Where termination by culture is impracticable, terminate at 16 days after onset.	1. Quarantine: All contacts who handle food until shown by bacteriological examination not to be carriers. 2. Observation: Daily for 15 days following last exposure. 3. Immunization: All Schick-positive contacts should be actively immunized with toxoid (in order to minimize local and constitutional reactions it is desirable to make a preliminary "toxoid reaction test," nonreactions to receive multiple small doses of suitably diluted toxoid).	1. Concurrent disinfection: Of all articles soiled by discharges from patients, and all articles that have been in contact with patient. 2. Terminal disinfection: Thorough cleaning or renovation and thorough airing and sunning of sick room.
Dysentery, balantidic (amebic).	1. Recognition by clinical symptoms confirmed, if possible, by microscopic examination of stools. 2. Isolation: None (but patients should be instructed regarding hand washing and forbidden to handle food to be eaten by others until repeated microscopic examination of stools shows absence of the *Entamoeba histolytica*).	1. Quarantine: None. 2. Immunization: None. 3. Microscopic examination of stools of work associates of patient.	1. Concurrent disinfection: Sanitary disposal of bowel discharges. Hand washing after use of toilet. 2. Terminal disinfection: Cleaning. 3. Search for direct contamination of water and food by human feces. 4. Check against possibility of water pollution by cross-connection and back-flow connection.

Dysentery, bacillary	1. Recognition by clinical symptoms; confirmation if possible by laboratory tests. 2. Isolation: During acute phase of disease and until the dysentery bacilli are absent from the bowel discharges. Food handling forbidden until stools negative.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection of all bowel discharges. Hand washing after use of toilet. 2. Terminal disinfection: Cleaning. 3. Search for contamination of water, milk and food by human feces.
Encephalitis, lethargic	1. Recognition by clinical symptoms assisted by microscopical and chemical examination of spinal fluid if possible. 2. Isolation: For 1 week after onset.	1. Quarantine: None. 2. Immunization: None. 3. Search for unreported cases amongst shipmates. 4. Observation of close contacts every 2d day for 21 days.	1. Concurrent disinfection of discharges from the nose, throat, and bowel, and articles soiled therewith. 2. Terminal disinfection: None. 3. Take such steps as are practicable in controlling or preventing contact with mosquitoes.
Erysipelas	1. Recognition by clinical manifestations confirmed if possible by bacteriological means. 2. Isolation: Until lesions are completely healed. 3. The use of appropriate sulfonamides may reduce the communicability.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: Discharges from lesions and articles soiled therewith. 2. Terminal disinfection: Thorough cleaning.
Favus	1. Recognition on clinical manifestations confirmed if possible by microscopic examinations of crusts and cultures on Sabouraud's medium. 2. Isolation: Yes, until skin and scalp lesions are healed and microscopic examination is negative. Patient should wear a tight-fitting cotton skullcap which is boiled frequently.	1. Quarantine: None. 2. Immunization: None. 3. Instruction of contacts to report to medical officer the occurrence of any scalp lesions.	1. Concurrent disinfection: Toilet articles of patient. 2. Terminal disinfection: None. 3. Check against use of common hair brushes and combs.

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Filariasis	1. Recognition on clinical manifestations—confirmation by finding embryos in blood after symptoms have occurred. 2. Isolation: Not practicable because of prolonged period of communicability. Patient should be made inaccessible to mosquitoes.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection. 2. Anti-mosquito measures particularly against *Culex fatigans:* screening of all sleeping quarters with screens eighteen mesh to the inch. 3. Terminal disinfection: None.
Fungus infection of the skin (ringworm).	1. Recognition on clinical manifestations. 2. Isolation: No, but severe cases should be excluded from common bathing facilities until condition reasonably well cleared.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection. Cleanliness of body and underclothes. Use of cotton socks which can be boiled. Use of formaldehyde or powdered acetylsalicylic acid for disinfection of shoes. 2. Terminal disinfection: None. 3. Survey of common bathing facilities to assure all precautions being taken.
German measles (rubella).	1. Recognition by clinical manifestations. 2. Isolation: From onset of catarrhal symptoms or rash until disappearance of rash.	1. Quarantine: None. 2. Immunization: None. 3. Non-immune contacts of first cases should be observed every second day (particularly looking for post-auricular nodes) for 21 days from the last day of exposure. Observation of contacts when the disease is epidemic is probably futile.	1. Concurrent disinfection: All articles soiled with the secretions of nose and throat. 2. Terminal disinfection: Thorough cleaning.

Glanders	1. Recognition by clinical manifestations followed if possible by the complement fixation test, the mallein test, the agglutination test or the Straus reaction and confirmation by culture and identification of *Bacillus mallei*. 2. Isolation: Yes, until bacilli disappear from discharges or until lesions have healed.	1. Quarantine: None. 2. Observation of close contacts daily for 5 days. 3. Immunization: None.	1. Concurrent disinfection: Discharges from patient and articles soiled therewith. 2. Terminal disinfection: Thorough cleaning. 3. Search for any infected horses.
Gonorrhea including: Gonococcus infection, all types.	1. Recognition by clinical manifestation confirmed, if possible, by bacteriological examinations. In absence of laboratory facilities treatment of acute purulent urethral discharges should begin anyway, a smear for subsequent examination first being procured. 2. Isolation: Placed on "venereal restricted list" and refused all shore leave until discharges disappear. 3. Patient instructed regarding care of hands and discharges until declared cured. 4. Education: Stressing (a) that continence is compatible with health and normal development, (b) that prophylaxis is available and advisable if self-control has failed and promiscuous sexual intercourse has occurred. 5. Proper treatment with appropriate chemotherapeutic agents such as sulfathiazole or sulfadiazine should be useful in limiting communicability.	1. Quarantine: None. 2. Immunization: None. 3. Search made for infected person from whom patient received infection. Report made to proper authorities to bring about control and treatment of the spreader.	1. Concurrent disinfection: Discharges from lesions and articles soiled therewith. 2. Terminal disinfection: None. 3. Check against common use of towels and toilet articles.

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Hookworm disease	1. Recognition by clinical manifestations confirmed by finding ova in feces. 2. Isolation: None. 3. Treatment with tetrachlorethylene, hexylresorcinol or carbontetrachloride should reduce the communicability.	1. Quarantine: None. 2. Immunization: None. 3. Education as to dangers of spread through soil.	1. Concurrent disinfection: Sanitary disposal of bowel discharges to prevent contamination of soil and water. 2. Terminal disinfection: None.
Impetigo contagiosa	1. Recognition on clinical manifestations. 2. Isolation: Yes, until pustules are healed.	1. Quarantine: None. 2. Immunization: None. 3. Instruct contacts to report any skin lesions promptly to medical officer.	1. Concurrent disinfection: Sanitary disposal of dressings and moist discharges from lesions. 2. Terminal disinfection: None. 3. Check against use of common towels.
Influenza	1. Recognition by clinical symptoms only (very difficult in interepidemic periods). 2. Isolation: During acute stages of disease, especially in severe cases and those complicated by pneumonia.	1. Quarantine: None. 2. Immunization: None. 3. Instruction: Report promptly to physician if feeling feverishness.	1. Concurrent disinfection: Discharges from nose and throat. 2. Terminal disinfection: None. 3. Increase separation of individuals and reduce crowding. 4. Improve ventilation of living and sleeping quarters. 5. Check efficacy of dish washing facilities.
Jaundice, epidemic (Weil's disease).	1. Recognition on clinical manifestations (confirmation if possible by isolation of Leptospirae from blood or urine and positive serological tests). 2. Isolation: None.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: Urine and other discharges of the patient. 2. Terminal disinfection: None. 3. Check rat-control measures. 4. Protect workers in infected water, with boots and gloves.

Leprosy	1. Recognition on clinical symptoms confirmed by microscopic examination where possible. 2. Isolation: Yes, transfer to national leprosarium as soon as possible.	1. Quarantine: None. 2. Immunization: None. 3. Search made for infected person from whom patient received infection.	1. Concurrent disinfection: Discharges and articles soiled with discharges. 2. Terminal disinfection: Thorough cleaning of patient's quarters.
Lymphogranuloma venereum.	1. Recognition on clinical manifestations (diagnosis should be confirmed by Frei antigen intradermal test). 2. Isolation: Placed on "venereal restricted list" and refused all shore leave and the handling of all food as long as there are open lesions on the skin or mucous membranes. 3. Education: Stressing (a) that continence is compatible with health and normal development, (b) that prophylaxis is available and advisable if self-control has failed and promiscuous sexual intercourse has occurred. 4. Proper treatment with appropriate chemotherapeutic agents such as sulfathiazole, sulfadiazine or sulfanilamide may be useful in limiting communicability.	1. Quarantine: None. 2. Immunization: None. 3. Search for case of origin particularly among prostitutes, among persons of Negro race, and among former residents of tropical and subtropical areas. Report made to proper authorities to bring about control and treatment of this spreader.	1. Concurrent disinfection: Discharges and articles soiled therewith. 2. Terminal disinfection: None. 3. Check against common use of towels and toilet articles.
Malaria	1. Recognition by clinical manifestations always confirmed if possible by microscopical examination of the blood. 2. Isolation: From mosquitoes only. 3. Proper treatment with appropriate chemotherapeutic agents such as quinine, atabrin and/or plasmochin should be useful in limiting communicability.	1. Quarantine: None. 2. Immunization: None. 3. Administration of suppressive doses of quinine or atabrin for all those who have been or still are exposed to *Anopheles* mosquitoes. (0.2 gram (3 grains) atabrin twice a week or 0.3 gram (5 grams) quinine sulfate daily.	1. Concurrent disinfection: None. Destruction of *Anopheles* mosquitoes in patient's quarters. 2. Terminal disinfection: None Destruction of *Anopheles* mosquitoes in patient's quarters. 3. Killing mosquitoes in all living quarters. 4. Screening sleeping and living quarters (use of screening at least 16 wires to the inch).

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Measles (rubeola)	1. Recognition on clinical manifestations with special attention to rise of temperature, Koplik spots, and catarrhal symptoms in exposed individuals. 2. Isolation: During the period of catarrhal symptoms and until the cessation of abnormal secretions.	1. Quarantine: None. 2. Observation: Of all nonimmune contacts daily for period of 21 days. 3. Immunization: Not as a rule. In exceptional cases injection nonimmunes with 3 to 6 cc. of immune globulin or 20 to 50 cc. of the whole blood of immunes or 4 to 10 cc. of convalescent measles serum, within 5 days after first exposure may be used with the hope of averting an attack.	1. Concurrent disinfection: All secretions of nose and throat and articles soiled therewith. 2. Terminal disinfection: Thorough cleaning.
Mumps (parotitis, epidemic).	1. Recognition on clinical manifestations. 2. Isolation: For period of swelling of a salivary gland.	1. Quarantine: None. 2. Observation: All exposed nonimmunes daily for period of 21 days from date of last exposure. 3. Immunization: None. (Passive temporary immunization by convalescent serum or blood may be used.)	1. Concurrent disinfection: None. 2. Terminal disinfection: None.
Paratyphoid fever.....	1. Recognition on clinical manifestations confirmed, if possible, by specific agglutination test or by bacteriological examination of blood, bowel discharges or urine. 2. Isolation: In flyproof room until repeated bacteriological examination of discharges shows absence of the infecting organism.	1. Quarantine: None. 2. Immunization: Exposed susceptibles to be reinoculated with "booster dose" of triple typhoid vaccine (0.1 cc. intracutaneously).	1. Concurrent disinfection of all bowel and urinary discharges and articles soiled with them. 2. Terminal disinfection: Cleaning. 3. Check sanitation of water, milk, shellfish, or other food. 4. Check for unreported cases or carriers among food handlers.

Pediculosis.	1. Recognition by direct inspection for lice and nits. 2. Isolation: Yes; until lice are destroyed and nits removed from hair. 3. Proper treatment should be useful in limiting communicability.	1. Quarantine: None. 2. Inspect heads, bodies and clothing contacts.	1. Concurrent disinfestation: Such washing of person and treatment of body clothing and toilet articles as will destroy lice and nits. 2. Terminal disinfestation: None. 3. If infestation found general, institute disinfestation procedure for entire personnel of ship.
Plague (bubonic) (pneumonic).	1. Recognition by clinical manifestations confirmed if possible by; (a) bacteriological examination of blood or pus from glandular lesions, or sputum; (b) animal inoculation. 2. Isolation: In a screened room free from vermin until complete recovery (masks, gowns and gloves must be worn by those coming in contact with case).	1. Quarantine: Of all contacts of pneumonic cases for 7 days take temperatures every 12 hrs. 2. Immunization: Reinoculation of ship's personnel with "a booster dose" of 1 cc. plague vaccine is indicated. Those not previously immunized should have the full course of immunization.	1. Concurrent disinfection: Sputum and articles soiled therewith in pneumonic type of disease. 2. Terminal disinfection: Thorough cleaning followed by fumigation to destroy rats and fleas. Bodies of persons dying of plague to be handled under strict antiseptic precautions. 3. Check rat proofing of ships and presence of fleas.
Pneumonia (lobar) (primary, atypical).	1. Recognition by clinical manifestations. Bacteriological and serological tests should be done if possible. 2. Isolation: Yes, until sputum no longer carries the infectious agent. 3. Prompt treatment with an appropriate chemotherapeutic agent such as sulfadiazine may be useful in limiting communicability.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: Discharges from nose and throat of patient. 2. Terminal disinfection: Thorough cleaning and airing. 3. Increase separation of individuals and discourage crowding.

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Poliomyelitis	1. Recognition by clinical manifestations assisted if possible by microscopical and chemical examinations of the spinal fluid. 2. Isolation: Yes, for 2 weeks from onset.	1. Quarantine: No (but nonimmune exposed food handlers must not handle food to be eaten uncooked for 14 days from last exposure). 2. Observation: Of all nonimmune close contacts daily for 14 days from last exposure. 3. Immunization: None.	1. Concurrent disinfection: Nose, throat, and bowel discharges, and articles soiled therewith. 2. Terminal disinfection: None.
Psittacosis	1. Recognition by clinical manifestations. Confirmatory laboratory tests usually not available on board ship. 2. Isolation: Yes, during febrile and acute clinical stage. (Those handling patients with a cough should wear masks with 8 layers of gauze 40–48 threads per inch or 16 layers of gauze 20–24 threads per inch).	1. Observation of close contacts of patient daily for period of 15 days following last exposure. 2. Immunization: None.	1. Concurrent disinfection; Of all discharges. 2. Terminal disinfection. Thorough cleaning. 3. Quarantine: Quarters which housed infected birds should be quarantined until thoroughly cleaned and disinfected. 4. Incriminated birds should be killed, their bodies immersed in 2 percent cresol, their spleens aseptically removed, part placed in equal parts of sterile glycerin and standard phosphate buffer solution of pH 7.5, and part in a suitable fixative and both specimens sent to the nearest available laboratory for examination. Carcasses should be burned before feathers dry.
Rabies	1. Recognition of disease by clinical symptoms confirmed if possible, by examination of brain of animal for Negri bodies and	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection of saliva of patient and articles soiled therewith. 2. Terminal disinfection: None.

	by animal inoculations with material from the brain of such animal. 2. Isolation: None if patient is under medical supervision and attendants are warned of possibility of inoculation by human virus. 3. Immunization: Semple vaccine should be given promptly to patient bitten or mouthed over by animal seriously suspected of being or proved to be rabid.		
Rat bite fever	1. Recognition of disease by history of rat bite and symptoms. Means of laboratory confirmation rarely available on ship board. Prompt cure by arsphenamines is of diagnostic value. 2. Isolation: None.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: None. 2. Terminal disinfection: None. 3. Rat eradication and prevention of rat bites.
Relapsing fever	1. Recognition by clinical symptoms, confirmed if possible by laboratory means; curative action of arsphenamines also confirmatory. 2. Isolation: None.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: None. 2. Terminal disinfection: None. 3. Tick and louse eradication.
Rocky Mountain spotted fever.	1. Recognition by symptoms and history of tick bite or exposure to ticks. A positive Weil-Felix reaction during the second week of illness is a valuable confirmatory aid. 2. Isolation: None.	1. Quarantine: None—not communicable from man. 2. Immunization: Active artificial immunization by Spencer-Parker vaccine has given very encouraging results.	1. Concurrent disinfection: All ticks on the patient should be destroyed. 2. Terminal disinfection: None. 3. Tick infested areas should be avoided as far as feasible; ticks should be promptly removed from person; hands should be protected when removing ticks from animals.

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Sandfly fever (pappataci fever).	1. Recognition by symptoms and history of exposure to bite of sandfly (genus phlebotomus). 2. Isolation: No; but every effort should be made to prevent infection of *Phlebotomus* by preventing them from gaining access to the patient during the first day of the disease.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: None. 2. Terminal disinfection: None. 3. Sandfly-infested areas should be avoided as far as possible. 4. Electric fans placed at openings will aid in preventing entrance of the flies. Screens must be 45 mesh to the inch to be effective. 5. Repellents may be helpful.
Scabies	1. Recognition by clinical manifestations. 2. Isolation: Yes; until itch mites and eggs are destroyed.	1. Quarantine: None. 2. Search contacts for unrecognized cases.	1. Concurrent disinfestation: Yes; of body clothing and bedding. 2. Terminal disinfestation: Underclothing and bedding to be so treated by dry heat or washing as to destroy the mites and the eggs.
Scarlet fever	1. Recognition by clinical symptoms. Schultz-Charlton blanching phenomenon may be helpful. 2. Isolation: Yes; until all abnormal discharges have ceased and all open sores on wounds healed (at least 21 days from onset). 3. Observation of all close contacts daily for week following last exposure with isolation of those with sore throat or upper respiratory infection until their symptoms have cleared.	1. Quarantine: No (exclusion of nonimmune food handlers from their work for period of 7 days from last day of exposure). 2. Immunization: (Usually none. In very special cases passive immunization by the injection of human convalescent serum or scarlet fever antitoxin in Dick-positive contacts).	1. Concurrent disinfection: All articles that have been in contact with patient and all articles soiled by discharges of patient. 2. Terminal disinfection: Thorough cleaning. 3. Study of possible milk or food source.

Schistosomiasis.	1. Recognition on clinical manifestations and if possible by microscopical examination of the stools or urine for ova. 2. Isolation: None. 3. Treatment with sodium antimony tartrate, fuadin or other trivalent antimony compounds should reduce communicability.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: Sanitary disposal of feces and urine. 2. Terminal disinfection: None. 3. Protect workers in polluted waters with boots, gloves, and other waterproof garments.
Septic sore throat	1. Recognition by clinical manifestations aided if possible by bacteriological examination of the lesions or discharges. 2. Isolation: Yes, until cured (exclusion from food handling until throat cultures clear of helmolytic streptococci).	1. Quarantine: None. 2. Immunization: None. 3. Observation of close contacts daily for period of 3 days from last exposure.	1. Concurrent disinfection: Articles soiled with discharges from nose and throat of patient. 2. Terminal disinfection: Cleaning. 3. Investigate milk supply.]
Smallpox	1. Recognition by clinical manifestations. 2. Isolation: In screened quarters, free from vermin until patient has recovered and all scabs and crusts have disappeared.	1. Immunization: Revaccination immediately of entire personnel of the ship. 2. Quarantine, For those contacts vaccinated within 24 hours of first exposure, quarantine until height of reaction is passed. For those contacts not vaccinated within 24 hours of first exposure, quarantine for 16 days from last exposure. 3. Meticulous search for prior case, particularly checking cases previously diagnosed as chickenpox.	1. Concurrent disinfection: Of all discharges. No articles to leave the surroundings of the patient without boiling or equally effective disinfection. 2. Terminal disinfection: Thorough cleaning and disinfection of quarters.

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Syphilis	1. Recognition by clinical manifestations confirmed by microscopical examinations of discharges and by serum reactions. 2. Isolation: Placed on "venereal restricted list" and refused all shore leave until non-infectious. (Infectiousness is not to be predicated on a blood test result, but upon the total time of course, laboratory tests, physical inspection, and treatment summation of the case). 3. Education: Stressing (a) that continence is compatible with health and normal development; (b) that prophylaxis is available and advisable if self-control has failed and promiscuous sexual intercourse has occurred.	1. Immunization: None. 2. Quarantine: None. 3. Search made for infected person from whom patient received infection. Report made to proper authorities to bring about control and treatment of this spreader.	1. Concurrent disinfection of all discharges and articles soiled therewith. 2. Terminal disinfection: None. 3. Check against common use of towels and toilet articles.
Tetanus	1. Recognition by clinical manifestations confirmed if possible by bacteriological means. 2. Isolation: None.	1. Quarantine: None. 2. Immunization: All wounded or tetanus-exposed persons should be given a "booster dose" of ½ cc. of alum-precipitated tetanus toxoid intramuscularly.	1. Concurrent disinfection: None. 2. Terminal disinfection: None.
Trachoma	1. Recognition on clinical manifestations. 2. Isolation: Not necessary if patient is receiving appropriate chemotherapy and is properly instructed regarding precautions against spread of secretions	1. Quarantine: None. 2. Immunization: None. 3. Search contacts for previously unrecognized cases. 4. For closest contacts the prophylactic use of suitable agents such as solution of zinc sulfate	1. Concurrent disinfection: Of discharges and articles soiled therewith. 2. Terminal disinfection: None. 3. Check against common use of towels and toilet articles.

	of the eye to others by common use of articles.	(1 percent), or copper sulfate (0.5 percent) may be useful as an eye wash.	
Trench fever	1. Recognition on clinical manifestations with history of exposure to the bite of the body louse. 2. Isolation: In vermin-free quarters until clinical recovery (recovered cases may remain infective to lice for several months).	1. Quarantine: None. 2. Immunization: None. 3. Through disinfestation of all contacts of patients.	1. Concurrent disinfection: Destroy all lice and louse eggs on hair, clothing, and bedding. Disinfection of urine and saliva and articles soiled therewith. 2. Terminal disinfection: None.
Trichinosis	1. Recognition on clinical symptoms and marked eosinophilia aided if possible by intradermal and precipitin tests. Confirmation by muscle biopsy after third week. 2. Isolation: None.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: None. 2. Terminal disinfection: None. 3. Every effort should be made to trace source of infection in pork and pork products. 4. Check thorough cooking of meat.
Tuberculosis (pulmonary) including: Tuberculosis, skin.	1. Recognition by clinical signs and symptoms confirmed by bacteriological examinations. 2. Isolation: None (but patients with open lesions must be forbidden to handle food).	1. Quarantine: None. 2. Immunization: None. 3. Special search for possible original source.	1. Concurrent disinfection: Discharges and articles freshly soiled with them. 2. Terminal disinfection: Cleaning. 3. Special investigation of milk source.
Tuberculosis (pulmonary) including: Tuberculosis, general miliary.	1. Recognition by use of x-ray followed by thorough physical examination supplemented by tuberculin testing when necessary and confirmed by bacteriological examination of sputum and other materials. Physical examination alone can rarely diagnose incipient case. 2. Isolation: Of "open" cases.	1. Quarantine: None. 2. Immunization: None. 3. All contacts of an "open" case should be examined roentgenologically. This should be repeated after 6 months.	1. Concurrent disinfection of sputum and articles soiled with it. 2. Terminal disinfection: Cleaning and renovation.

SPECIFIC MEASURES FOR DISEASE PREVENTION ON BOARD SHIP—Continued

Diseases (in alphabetic order)	Measures applicable to patient	Measures applicable to contacts	Measures applicable to patients' discharges and to environment
Tularemia	1. Recognition by clinical manifestations confirmed by bacteriological and serological means if possible (skin reaction less reliable). 2. Isolation: None.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection of discharges from the ulcer, lymph nodes, or conjunctival sac. 2. Terminal disinfection: None. 3. Special investigation of prevalence of blood-sucking flies and ticks, if possibility of use of raw drinking water, of the dressing of wild game without gloves.
Typhoid fever	1. Recognition by clinical manifestations confirmed if possible by specific agglutination test and bacteriological examinations. 2. Isolation: In fly-proof quarters until 2 successive negative cultures of stool and urine (collected not less than 24 hours apart) are obtained.	1. Quarantine: None. 2. Immunization: Yes, of ship's personnel with 0.1 cc. "booster dose" of triple typhoid vaccine intracutaneously.	1. Concurrent disinfection: Disinfection of all bowel and urinary discharges and articles soiled with them. 2. Terminal disinfection: Cleaning. 3. Investigate water, milk, shellfish, and food supply.
Typhus fever	1. Recognition by clinical manifestations confirmed if possible by a Weil-Felix reaction in the second week. 2. Isolation: In vermin-free quarters until the temperature has become normal and an additional 36 hours has elapsed (attendants should wear louse-proof clothing).	1. Quarantine: In the presence of lice, exposed susceptibles should be quarantined for 14 days after last exposure. 2. Observation: In the absence of lice, exposed susceptibles should not be quarantined but observed daily for 14 days after last exposure. 3. Immunization: Reinoculation of ship's personnel with 1 cc. typhus vaccine subcutaneously.	1. Concurrent disinfection: Destroy all lice and louse eggs on the clothing or in the hair of the patient. 2. Terminal disinfection: None. 3. Check methods for controlling lice, fleas and rats.

Undulant fever	1. Recognition by clinical manifestations supplemented by agglutination tests and bacteriological examinations, if possible, of the blood and urine for *Brucella*. 2. Isolation: None.	1. Quarantine: None. 2. Immunization: None.	1. Concurrent disinfection: Disinfection of urine and articles contaminated by urine. 2. Terminal disinfection: None. 3. Search for *Brucella* infection in goats, swine, or cattle. 4. Check on pasteurization of milk.
Whooping cough	1. Recognition by clinical manifestations supported by a differential leukocyte count showing a definite lymphocytosis. 2. Isolation: Yes; for period of 3 weeks from onset of paroxysmal coughing.	1. Quarantine: None. 2. All contacts instructed to report promptly to sickbay if they have any cough or cold within 16 days after last date contact. 3. Immunization: Not advised.	1. Concurrent disinfection: Discharges from the nose and throat and articles soiled therewith. 2. Terminal disinfection: Thorough cleaning.
Yaws (frambesia)	1. Recognition by clinical manifestations supplemented by serological tests if possible. 2. Isolation: Yes; in flyproof quarters, as long as there are open lesions or moist discharges. 3. Treatment as for early syphilis should reduce communicability.	1. Quarantine: None. 2. All contacts who have open wounds should be instructed to report promptly any unusual development in or about their wound to their medical officer. 3. Immunization: None.	1. Concurrent disinfection: Disinfection of all soiled dressings and linens. 2. Terminal disinfection: None. 3. Check fly control measures.
Yellow fever	1. Recognition by clinical manifestations. 2. Isolation: Yes; in screened quarters (from which all mosquitoes have been eliminated by fumigation, trapping, etc.) for the first 4 days of fever.	1. Immunization: Reinoculate ship's personnel with 0.5 cc. of a 1 : 10 dilution of a concentrated vaccine subcutaneously. 2. Quarantine: All those probably exposed, in quarters protected with 18-mesh screen for 10 days and inspect daily.	1. Concurrent disinfection: None. 2. Terminal disinfection: None except to destroy any mosquitoes in the patient's quarters.

IMMUNIZATION MEASURES USED IN NAVY

Biologic	Method of administration	Expected immunity and repeat indications	Comments
Cholera			
Vaccine—suspension of 8,000 million killed cholera vibrios per cc.	Two subcutaneous injections at 7- to 10-day interval consisting of 0.5 cc. and 1 cc. doses of vaccine respectively.	Apparently short duration of immunity. Stimulating dose of 1 cc. given every 4 to 6 months following initial vaccination as long as danger of infection exists.	No severe reactions have been reported. Given only to personnel in or traveling to areas where there is danger of endemic or epidemic cholera. Should, where practical, be given one month prior to entering area.
Smallpox			
Vaccine—cowpox virus plain, glycerinated.	Multiple pressure (needle held parallel to skin) 6 to 12 strokes in ⅛-inch area preferably on arm deltoid region. No dressings used. Expose lesion to air.	To be administered on enlistment. Revaccination upon re-enlistment or when doubt as to existing protection. Revaccinate whenever exposed and at intervals no greater than four years.	Vaccination reactions: *A. Immune reaction.*—Usually no vesicle. Maximum diameter of erythema reached and passed in 8 to 72 hours. Occurs in fully protected individual. *B. Accelerated reaction.*—Means partial loss of protection gained from a previous vaccination or attack. Maximum erythema diameter reached in 3 to 7 days. Usually a vesicle. *C. Primary reaction.*—Observed in unprotected individuals and previous unsuccessful vaccinations. Maximum erythema reached in 8 to 14 days. Always a vesicle.
Tetanus			
Toxoid—alum precipitated.	Two 0.5 cc. injections intramuscularly with interval not less than 4 or more than 8 weeks.	One year after initial immunization give a single booster injection of 0.5 cc. of alum precipitated tetanus toxoid intramuscularly. Further booster of 0.5 cc. when going into combat zone irrespective of time interval since previous injection. Should	Tetanus toxoid may be given concurrently with typhoid and smallpox. It is considered unnecessary to repeat the annual "booster."

		be given at least one month before entering combat zone. Upon being wounded or exposed to tetanus infection a further 0.5 cc. dose of toxoid is given irrespective of the time interval since previous injection.	
Triple (typhoid-paratyphoid)			
Vaccine—1,000 million bacteria (typhoid) per cc.; 250 million each of paratyphoid "A" and "B" organisms.	Subcutaneously 3 injections of 0.5 cc., 1 cc. and 1 cc. at weekly intervals. This is considered the standard course.	Intracutaneous injection of 0.1 cc. triple (typhoid-paratyphoid A and B) vaccine annually as a booster dose after the standard course has been received.	Tuberculin syringe should be used for the "booster" injection.
Typhus fever			
Vaccine—a suspension of killed epidemic typhus Rickettsiae prepared by Cox yolk-sac culture method.	Three subcutaneous injections of 1 cc. each at intervals of 7 to 10 days.	Stimulating dose of 1 cc. subcutaneously given every 4 to 6 months following initial vaccination as long as there is danger of epidemic typhus fever.	No severe reactions have been reported. Given to all personnel on active duty in areas where danger from epidemic typhus fever exists.
Yellow fever			
Vaccine—strain of living yellow fever virus attenuated through prolonged cultivation in tissue cultures (chick embryo).	0.5 cc. of 1:10 dilution of concentrated vaccine subcutaneously (one dose only).	All personnel routinely immunized. Immunization is lifelong but in presence of an epidemic of yellow fever another dose shall be given to increase the titer of immune bodies.	Vaccine must be kept at temperature not above 4° C. (39° F.). All diluted vaccine which remains unused after 3 hours must be discarded. Use only diluted vaccine. A very mild febrile reaction may occur in 4 to 7 days. Yellow fever vaccine should *not* be given concurrently with smallpox. Give yellow fever vaccine first and at least 5 days later give smallpox. Yellow fever vaccine may be given with typhoid or tetanus.

It has been suggested that personnel in extreme northern latitudes be given shots of antidiphtheria toxoid due to the fact that unimmunized persons are extremely susceptible to diphtheria the farther north they travel. This suggestion is under consideration by the Navy but is not yet a part of its immunization schedule.

CHAPTER XV

THE HOSPITAL SHIP

Hospital ships have amply justified their existence as a component of naval forces in time of peace as well as of war.

Since August 29, 1921, the basic administration of a hospital ship has been similar to that of any other ship in the U. S. Navy, "except insofar as departures therefrom are made necessary, in time of war, by the noncombatant status of the ship and the provisions of the Hague Convention of October 18, 1907."

By the Hague Convention of 1907 the distinctive markings of a hospital ship were delineated as follows: A green band of about 6 feet wide horizontally about the ship slightly above the water line, a large red Geneva cross amidships on each side and, very recently, a large red Geneva cross painted on the superstructure so that it may be readily observed from the air. While red and green lights for night use were also specified, they have been found to be impossible to use and usually flood lights are rigged for night time so that the distinctive markings of the ship may be observed for some distance. A hospital ship may not carry combatant arms except in very limited quantities for protection against savage or semicivilized enemy.

The ideal hospital ship is one which has been designed for that purpose, but experience has proved

that many merchant ships can be converted into efficient hospital ships and serve this purpose admirably. The ideal size of a hospital ship is about 10,000 gross tons. Smaller ships cannot carry a sufficient number of patients to warrant their maintenance, and it is difficult to maneuver larger ships into some of the more shallow harbors, especially in the Pacific area. Speed is an important factor. The ideal hospital ship should have sufficient speed to maintain its place with the main body of the fleet under all conditions, but unfortunately high speed means vibration, and vibration must be reduced as much as possible on a ship of this type. Cruising radius is an important factor in that the hospital ship must be able to stay with the fleet on long, fast cruises. Steadiness of operating platform is of paramount importance, hence the hospital ship should be designed, or a liner for conversion chosen, with that object in mind.

Ample provision must be made for the hoisting on board of patients when the ship is at sea where gangways cannot be used. Special jib-cranes of a simple design can readily be made and installed and it may turn out to be very practical to use boat davits for the same purpose. Nothing mechanical has yet been developed which can replace manpower in raising or lowering patients from or to boats alongside. It is not unusual for hospital ships to receive patients while cruising in company with the fleet, as is witnessed by the fact that on one peacetime cruise from the West Coast to Panama the U. S. S. *Relief* received 17 patients in 15 days. The ship must be provided with several four-legged bridles, each leg having a snap hook on the end so that they may be quickly and

safely snapped onto the Stokes stretchers in which the patients will normally arrive. While in port the ship would normally have its entry ports open, one or more on each side, and the gangways should be a minimum of 60 inches wide so that stretcher patients may be carried on board with ease. Even if a moderate sea is running while at anchor it will probably prove more satisfactory to use the hoisting gear for patients rather than to subject them to the jarring which occurs in removing a stretcher from the boat to the gangway landing.

The special mission of a hospital ship must be considered in laying out storage spaces for food as well as medical department equipment and supplies. Refrigerated spaces must be considerably in excess of those allowed other vessels of equal complement. It would be a wise provision to have on board a special refrigerator of sufficient capacity to carry an ample supply of the hard frozen food products such as meats, fowl, fish, and vegetables. On the U. S. S. *Solace* there is refrigerated storage space sufficient to carry 10 months' supply of perishable foods. Storage space for medical supplies and equipment is likewise an important problem and there again, sufficient space must be provided to carry at least 1 year's supply even if it means sacrificing bed space. It will be found to be more efficient to have a few large storerooms rather than a multitude of small ones.

Elevators must be provided for the handling of patients and stores, and the ideal situation would be a patient elevator at each end of the ship and a freight elevator serving storerooms and bag room. This necessitates careful design and assignment of spaces below

decks. Automatic elevators have proven far superior to the manually operated type.

Electric generating capacity should be considerably in excess of the immediate apparent needs and the type of current and voltage should be very carefully considered. Electricity for the x-ray department should be provided from a separate generating unit of sufficiently ample capacity to absorb all demands for current without undue voltage drop. If the electricity for the x-ray is taken from a common generator it will frequently happen that an elevator motor or other powerful piece of equipment starts at the same time that the x-ray is taken, with resultant spoilage of the film. Almost daily, new and desirable pieces of electric equipment may be introduced aboard and unless this contingency is allowed for, in a very short time the ship will be undersupplied with electric power. The same applies to the distilling apparatus in which the fresh water is made. All persons on board a hospital ship must be educated on the subject of fresh water conservation and yet it is necessary to have ample water for actual needs. Experience on the U. S. S. *Solace* has proved that an average of 60 gallons of water per day per person on board is sufficient to care for the fresh water needs of crew and patients.

Because of the nature of its mission, a hospital ship must contain all of the medical and surgical departments found in any well-equipped hospital ashore. The x-ray department should be in the immediate neighborhood of the surgical wards, particularly the traumatic surgical ward, and must have elevator service nearby. The clinical laboratory should be close to the operating rooms in order that the frozen section

FIGURE 31.—U. S. Hospital Ship *Solace*.

work may be expedited. The physical therapy department is the only one which can be curtailed. Generally speaking, patients are not retained on board a hospital ship for extended periods of time, hence there will not be need for prolonged physical therapy. The x-ray and laboratory equipment and personnel should be of the highest caliber, as it is usually impracticable if not impossible to obtain consultation from other institutions. The same applies to the equipment. Nothing should be eliminated with the thought of borrowing from someone else if needed.

Sterilizing equipment, up to and including a large mattress sterilizer, must be of the best. With modern innerspring mattress construction now in general use, the mattress sterilizer must be provided with a formaldehyde vapor attachment.

An animal house must be provided and is best located on the weather deck aft so that the usual animal odors may not permeate the whole ship. Considering global war, the animal house must be provided with ample ventilation as well as heating arrangements and adequate insulation against tropical sun.

An adequate incinerator must be provided to dispose of the large quantities of combustible rubbish and dressings, and in addition there must be oil-burning facilities for the complete incineration of amputated parts. Obviously this latter installation must be in the immediate vicinity of the ship's smokestack for the ready disposal of noxious vapors.

Contrary to common usage in hospitals ashore, the mortuary must be provided with refrigerating facilities for the preservation of the bodies of deceased personnel. An adequate autopsy room with proper hot- and cold-

water service and oversized deck drainage must be provided, preferably immediately contiguous to the mortuary. A competent embalmer is an essential member of the medical personnel.

The ward spaces must be located above the water line and should have large ports or windows open to the outside. A study of the records of the U. S. S. *Relief* for the past 16 years indicates that the following percentage distribution of beds in the different wards will prove the most satisfactory:

	Percent
Officers	3
Contagious and acute medicine	10
General medicine	9
Operative surgery	15
Traumatic surgery	15
Eye, ear, nose, and throat	7
Insane	1
Urological and skin	15
Convalescent wards	25
Total	100

There is an approved design for the stanchions on which the bunks are supported. These are of angle iron or H-bar type, and are so designed that the bunks may be either single-banked or double-banked as the need arises. Provisions must be made so that if the bunks are single-banked, the upper bunk not in use is well up out of the way so that it will not interfere with nursing procedures. All bunks and stanchions must be so designed and made that there will be no holes or crevices in which vermin may live and breed. The *cimices* are particularly prone to get into pipes or hollow stanchions where they breed at will and are almost impossible to eradicate.

FIGURE 32. — Hospital ship ward.

Open deck space, partly glassed in, will prove to be of the utmost value for airing and sunning both ambulatory and bed patients. Better still is a large sun deck on the top superstructure, preferably with elevator service, so that, weather permitting, the patients may be taken outside. This happy condition exists on both the U. S. S. *Relief* and the U. S. S. *Solace*. In order to take advantage of these open deck spaces, door combings should be kept as low as consistent with the safety of the ship, and ramps should be provided to permit wheeling stretchers and beds through the doors.

With modern air-conditioning units so readily available, the old accepted standards of a certain number of cubic feet of air space per patient no longer apply. The problem should be attacked from the angle of complete air change in the compartment per time limit. Ventilating units designed to give a complete change of air every three minutes have been found to be entirely satisfactory for use on board hospital ships. The units should be so constructed as to provide for warming, humidifying and cooling the air, all of which advantages will be found in the most modern units. The location of the ventilating outlets in the ward spaces must be carefully chosen, otherwise it will be found that certain beds will receive an overabundance of air and other beds will be undersupplied. The most efficient system is a combined supply and exhaust installation which will provide for a free circulation of air without undue draft on any one patient. (See chapter II, Ventilation).

Each ward should be provided with a small service pantry from which trays to bed patients can be served. The food very properly and efficiently can be brought from the galley to these ward pantries in electrically

heated food carts. The pantries should be equipped with accessory cooking equipment so that between-meal nourishment can readily be provided. A central scullery and dishwashing department will be found to be the most efficient. A garbage grinding and disposal unit has been developed and is now in use on one of our hospital ships (U. S. S. *Solace*). In this unit all garbage, except possibly some of the larger bones of a beef skeleton, is ground up, mixed with water and discharged overboard, thus doing away with the handling of large quantities of garbage. These units have been approved for use by the health authorities and port commissions of practically all of the larger ports in the United States. Obviously, separate scullery and dish washing machinery must be provided for the contagious and isolation wards of the ship. Deep compartmented trays composed of corrosion resisting metal—steel or duralumin—make for better service, ease of handling and prevent a great breakage of crockery, and they lend themselves perfectly to sterilization. They have been used with excellent success on hospital ships. Messing facilities for ship's company and ambulatory patients are best handled by the cafeteria system, and with proper installation it is practicable to serve up to 400 persons in 1 hour.

As female nurses are an accepted part of the ship's complement, consideration must be given to the nurses' quarters. While their presence on board a hospital ship is a definite asset, they nevertheless introduce problems that do not occur on other ships of the Navy. Indoor passageways from the nurses' quarters to all sick spaces must be provided; ample lounging space and recreation space are absolute essentials. While pri-

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vacy is usually a negligible feature in the life of a man, to most women it is of paramount importance, hence it will be best if the quarters can be so designed as to permit individual occupancy of rooms. A small, efficient laundry for the nurses should be provided in their quarters.

Laundry facilities should be designed considerably in excess of the apparent load. Ten pounds of laundry per day per patient should be the very minimum provided for, with an additional allowance of 2 pounds per day for the ship's company. An expert laundryman must be provided, both for the efficient operation of the laundry and the proper conservation of fresh water, as inexperienced help usually prove more of a liability than an asset.

Deck covering is of great importance. Operating rooms, scrub-up rooms, pantries, toilets, autopsy room and other spaces in which the deck is usually wet, are best covered with a nonslip tile. The conventional wooden gratings in baths can and should be eliminated by the use of such nonslip tile, which can be sterilized readily either by boiling water or chemical means. Wooden gratings have been found to be a prolific source of fungus infection in the feet and have no place on board modern ships. The deck coverings in the wards must be fireproof, somewhat resilient and not too slippery. It has been found that magnesite compounds properly laid satisfy all these requirements. Linoleum may be a very definite and serious fire hazard, in that it is moderately inflammable and when burning throws off a dense suffocating smoke.

One of the difficulties in the design of a hospital ship is to isolate noise-making machinery. Such installation

as boat and cargo-hoisting winches, ventilating blowers, pumps and other noise-making machinery must be very carefully considered with a view towards obtaining units as nearly noiseless as possible and, even so, it may be necessary to locate them in such places as to prevent the transmission of noise through the metal structure of the ship to ward spaces. One has but to consider how irritating these noises can be to a well person, to appreciate the importance that they will assume to a sick one. Elevator shafts should be completely enclosed and soundproofed. Winches may have to be installed on vibration dampers with soundproofing between the winch bed and the decking. The same applies to the ventilating blowers.

The psychopathic ward should be located as far away from the other ward spaces as possible, probably on the superstructure well aft so that possible noise from this department may not keep other patients awake day and night.

Chapter XVI

THE DENTAL OFFICER ABOARD SHIP

Surprise is often expressed that the naval dental officer serves afloat as well as ashore. Before discussing his duties while at sea, it might be well to describe the dental office, its personnel and various types of dental equipment found aboard ship.

In accordance with the desire of the Navy to improve the physical condition of its fighting men, dental facilities aboard ship have expanded and improved rapidly both as to the amount of office space allotted and extent of treatment administered. For instance, the larger combatant ships, such as the new battleships and aircraft carriers usually have three dental offices; cruisers have sufficient space for one. Destroyers and submarines are dependent upon their tenders for dental care. These offices are equipped with the most modern dental operating units, operating chairs, instrument cabinets, sterilizers, roentgenographic equipment and instruments so that routine operative and minor oral surgical procedures may be carried out efficiently.

Hospital ships and certain others acting as tenders are equipped with prosthetic laboratories as well as the standard dental office. These laboratories permit the construction of oral prosthetic appliances to replace missing teeth. Materials available for such treatment include acrylic resins, precious and nonprecious metals,

porcelains and all materials and equipment incident to partial and full denture impression-taking and processing. In addition, hospital ships offer oral surgical facilities for more advanced and extensive treatment.

A dental technician holding the rating of pharmacist's mate is assigned to assist each dental officer. He has

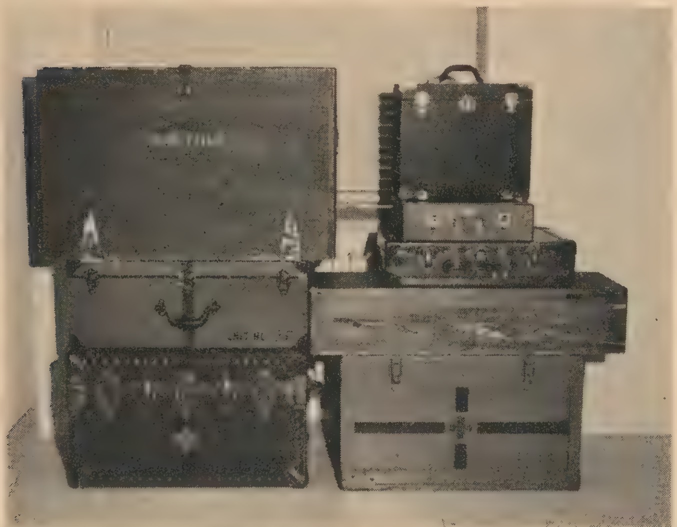

FIGURE 33.—Portable dental landing outfit.

received adequate training in carrying out routine dental procedures. The technician scales and polishes teeth and in general carries out duties similar to those performed by a dental assistant in private practice. The dental technician and other hospital corpsmen must also assist in the battle-dressing stations under the direction of medical and dental officers. When roentgenographic examination of the extremities is required by the medical

officer, the dental technician, under the supervision of the dental officer, makes the necessary roentgenogram. The dental x-ray unit is the only equipment of this type located aboard combatant ships.

As to specific duties, the dental officer directs his efforts toward several main goals which are taken up separately.

Preventive dentistry.—This includes education of the ship's personnel in proper oral hygienic measures.

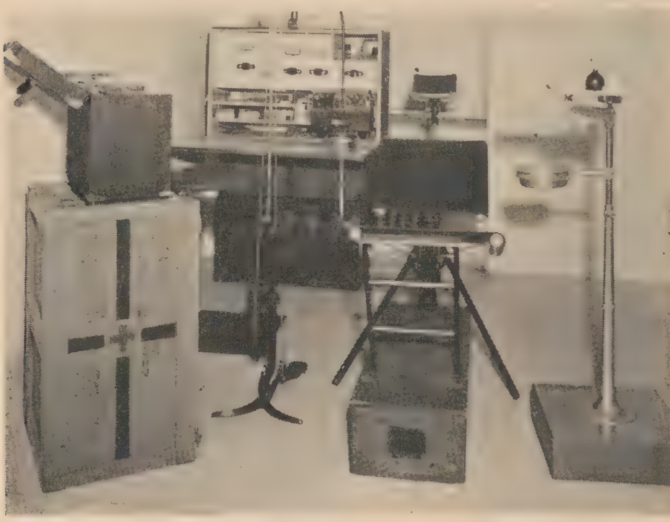

FIGURE 34.—Portable dental landing outfit installed.

This may be accomplished by visual education, by talks to individuals or groups and by the adoption of certain definite sanitary precautions. Proper methods of daily oral hygiene are continuously stressed.

Great emphasis is placed on the necessity for proper diet. Aboard some ships, medical, dental, and supply

officers collaborate in planning correct menus for daily rations. The inclusion of fresh fruits, vegetables, and dairy products is stressed. Ingestion of proper foods cannot be emphasized too thoroughly since common gingival disturbances, particularly noticeable when at sea for extended periods, can be attributed in many cases to improper food intake.

The danger of infecting oral tissues by the use of improperly sterilized drinking cups, glasses, and utensils is repeatedly impressed upon the ship's personnel, particularly when visiting places ashore where adequate precautionary measures are not rigidly enforced.

Routine examination of ship's company both clinically and by the use of bite-wing roentgenograms aids in detection of carious lesions. Prompt treatment of the personnel's dental needs lessens the degree of tooth destruction and prevents to a great extent apical involvement which might act as a focus of infection.

Routine clinical procedures.—Dental treatment available to ship's personnel includes restorations of amalgam or porcelain, simple extractions, elimination of oral infections and minor oral surgery. Since hospital ships are not always in the vicinity, it is necessary for dental officers to be thoroughly acquainted with routine oral surgical procedures. These include removal of impacted teeth, alveolectomy, apicoectomy, excision of cysts, and treatment of jaw fractures.

The dental officer must be thoroughly familiar with oral lesions, particularly those which are manifestations of systemic disorders. These cases may then be referred to the medical officer for treatment.

The dental officer must check the health records of all personnel periodically in order to keep the dental

record up to date. In many instances, this record, which contains a detailed diagram of all restorations present in the teeth, is the only means of identification of the dead.

Special clinical procedures.—During battle, the dental officer is in charge of one of the battle-dressing stations with corpsmen and other enlisted personnel as

FIGURE 35.—Dental office at a naval dispensary.

assistants. These men must be instructed in various duties pertaining to first aid, handling of casualties, identification of dead and in maintaining communications with "Central." The dental officer must have a complete understanding of the ship's plans involving damage control procedure with reference to the compartment in which the dressing station is established. This is necessary in order to maintain watertight integ-

rity and to protect and evacuate the wounded for whose safety he is responsible. The dental officer must also check dressings, drugs and supplies at his station.

As to professional duties, the dental officer assists the medical officer in emergency treatment of battle casualties. He must be thoroughly familiar with first-aid measures such as arresting hemorrhage, treatment of burns, proper bandaging, alleviation of pain and use of splints. He must understand wound debridement, particularly in regard to facial wounds in order to save as much tissue and attached bone fragments as possible for purposes of regeneration and repair. Administration of plasma in the treatment of shock and burns and application of sulfonamide drugs must be understood. He must be familiar with clearing and maintaining air passages in mandibular wounds where tongue control is lost.

The dental officer must also aid in sorting of wounded for immediate treatment or transfer. Aboard some ships, he is in charge of evacuating the sick from the sickbay. For this duty, he is given the services of several corpsmen. In this capacity, he must be sure that life jackets are properly adjusted on all patients, that they are correctly tagged and evacuated to proper stations as soon as possible with the least additional injury.

Dental officers attached to units engaging in landing operations must set up proper dressing stations for treatment of casualties. The portable dental supplies and other medical stores and equipment are placed aboard ship where quick removal is possible. In such operations, the dental officer and his assistants must be prepared to protect their wounded by force if necessary. This requires carrying of small arms and a

FIGURE 36.—Dental office on a carrier.

knowledge of their use so far as is permitted by international agreement.

General duties.—There are times when the dental officer must assume other duties not related to his professional training. He may be elected mess treasurer or assigned to the auditing board. He may also serve as a member of a naval courts-martial.

By nature of his profession, the dental officer comes in close contact with most of the ship's company. During their professional visits to the dental office, he may often have the opportunity to exert some influence on the morale and mental attitude of the personnel as well as to care for their dental needs.

Chapter XVII

SUBMARINE MEDICINE

A submarine is a vessel so constructed that it can either cruise on the surface or submerge and proceed below the surface. This type of ship has a cigar-shaped hull, built to withstand great pressure, and a free-flooding superstructure which forms the weather deck. When on the surface these vessels are propelled either by direct-drive Diesel engines or Diesel-electric combinations. When submerged they operate on electric motors driven by current from storage batteries made up of 120 to 252 1-ton lead-acid cells. These batteries are charged by Diesel operated generators. When submerged visual contact with the surface is maintained (to a keel-depth of about 60 feet) by means of periscopes. On the surface communication is accomplished either by visual or radio signals. While submerged radio reception is possible. Compartmentation by watertight, thwart-ship bulkheads divides the pressure hull into several sections. In the later type of submarines these are: The forward torpedo room, the forward battery room or officers' quarters; the control room; the after battery or crew's quarters; the engine rooms; the maneuvering room; and the after torpedo room. Intercompartment passage is possible through small, quick-closing doors.

Submarines have main ballast tanks which are carried "dry" for surface operations and are flooded upon

and during submergence. These tanks are so designed that their volume is exactly equal to the displacement of that part of the ship which is above the water line. When these tanks are flooded, the over-all weight of the ship exactly equals the over-all displacement and thus the ship is in neutral buoyancy. Depth control is effected by means of the forward motion of the ship and the use of bow and stern planes. Minor variations in weight caused by the addition or use of stores, fuel, etc., are compensated for by flooding or pumping the variable tanks. These tanks are: Forward trim, located in the forward part of the ship; auxiliary, at the center of gravity of the ship; after trim, at the after end of the ship. A trim pump and water manifold are installed for transfer of water between this group of tanks and the sea.

The submarine is brought to the surface by blowing the water from the main ballast tanks with compressed air.

Because of the unusual construction and function of these vessels there are numerous problems of a medical nature which need emphasis, particularly air conditioning, diet, maintenance of health and sanitation, and selection of personnel. (See also section on Ventilation of Submarines in Chapter II.)

VENTILATION.

Proper ventilation on submarines is of primary importance. In a sealed compartment such as a submarine the air is vitiated by the consumption of oxygen and the production of carbon dioxide and moisture by the ship's company, by the production of heat from the machinery, gases from the cooking, the batteries and the lubricants, etc.; and during the charging of the bat-

teries, by hydrogen and under unusual circumstances, by chlorine gas.

The habitability of a submarine from the standpoint of atmospheric conditions depends upon such factors as pressure, movement, temperature, humidity, and constituents of the air.

(1) *Air pressure.*—The air in a submarine is normally under the same pressure as that of the outside air. During a dive the pressure increases slightly due to compression of the hull and to venting of the tanks inboard. However should an escape with the submarine escape appliance (the "lung") be necessary, the air pressure within the compartment which is being flooded must be permitted to increase until it equals the pressure of the sea water for the depth at which the submarine is submerged (which allows the opening of the escape hatch).

(2) *Air movement.*—While a submarine is operating on the surface in a calm sea, its ventilation may be accomplished naturally through the hatches. However it is often necessary to close all the hatches except the conning tower hatch and in that case air is taken through this hatch and the main induction system. Forced draft blowers take air through the main induction and distribute it into the various compartments of the ship. An exhaust system is provided which takes air from the various compartments and delivers it to the engine room where it is discharged through the engines.

When the vessel is submerged the air movement is controlled by the same system, except that air is no longer exhausted through the engines but is returned to the supply system through the air-conditioning unit.

which cools and dehumidifies it. These methods of air movement are supplemented by use of compartment electric fans and portable blowers.

(3) *Air temperature.*—The temperature within a submarine is often extremely high, especially in the Tropics. Running submerged some cooling is obtained by conduction through the hull on account of its contact with the cooler sea water. The newer type submarines are equipped with an air-conditioning plant. When the air-conditioning unit is functioning it effectively lowers the temperature and humidity. Submarines on extended patrols in tropical waters have reported that air conditioning makes a vital difference in the staying power of the crew.

(4) *Air humidity.*—The relative humidity of the air in a submarine can be determined by wet and dry bulb (psychrometer) reading (see table 7). This often approaches the saturation point, particularly during an extended submerged run. Moisture is given off from the skin and lungs at the rate of approximately one ounce per hour per man at rest. This amount is greatly increased by bodily activity. Moisture is also given off from the food in cooking and from the batteries by evaporation. High relative humidity with high temperature causes considerable discomfort to the crew. It causes the bulkheads to drip moisture, and makes all clothing, mattresses, etc., continually damp, thus adding to the health hazards among the crew.

(5) *Air constituents.*—Normally the air within a submarine operating on the surface does not vary greatly from outside air, but during extended submergence the composition of the air may become so

Air Temperatures.	Difference Between the Dry and Wet Thermometers																															Air Temperatures.
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
30	100	89	78	67	57	47	36	26	17	7																						30
35	100	91	82	73	65	54	45	37	28	19	12	3																				35
40	100	92	84	76	68	60	53	45	38	30	22	16	8	1																		40
45	100	92	85	78	71	64	58	51	44	38	32	25	19	13	7	1																45
50	100	93	87	80	74	67	61	55	50	44	38	33	27	22	16	11	6	1														50
56	100	94	88	82	76	70	65	59	54	49	43	39	34	29	24	19	16	10	6	1												55
60	100	94	89	84	78	73	68	63	58	53	48	44	39	34	30	26	22	18	14	10	6	2										60
65	100	95	90	85	80	75	70	65	61	56	52	48	44	39	35	31	28	24	20	17	13	10	6	3								65
70	100	95	90	86	81	77	72	68	64	60	55	52	48	44	40	36	33	29	26	23	19	16	13	10	7	4	1					70
75	100	95	91	87	82	78	74	70	66	62	58	55	51	47	44	40	37	34	31	27	24	21	19	16	13	10	7	5	2			75
80	100	96	92	87	83	79	75	72	68	64	61	57	54	51	47	44	41	38	35	32	29	26	23	20	18	15	13	10	8	6	3	80
85	100	96	92	88	84	80	77	73	70	66	63	60	56	53	50	47	44	41	38	36	33	30	28	25	22	20	17	15	13	11	9	85
90	100	96	92	88	85	81	78	75	71	68	65	62	59	56	53	50	47	44	41	39	36	34	32	29	26	24	22	20	17	15	13	90
95	100	96	93	89	86	82	79	76	72	69	66	63	60	58	65	52	49	47	44	42	39	37	35	32	30	28	25	23	21	19	17	95
100	100	97	93	90	86	83	80	77	74	71	68	65	62	59	57	54	51	49	47	44	42	39	37	35	33	31	29	27	25	23	21	100
105	100	97	93	90	87	84	81	78	75	72	69	66	64	61	58	56	53	51	49	46	44	42	40	38	35	33	31	30	29	26	24	105
110	100	97	94	90	87	84	81	78	76	73	70	67	65	62	60	57	55	53	50	48	46	44	42	40	38	36	34	32	30	28	27	110
115	100	97	94	91	88	85	82	79	76	74	71	69	66	64	61	59	57	54	52	50	48	46	44	42	40	38	36	34	33	31	29	115
120	100	97	94	91	88	85	83	80	77	75	72	70	67	65	62	60	58	56	54	51	49	47	45	44	42	40	38	36	35	33	31	120
125	100	97	94	91	88	86	83	80	78	75	73	70	68	66	64	62	59	57	55	53	51	49	47	45	43	42	40	38	37	35	33	125
130	100	97	94	91	89	86	83	81	78	76	74	71	69	67	65	62	60	58	56	54	52	50	49	47	45	43	42	40	38	37	35	130
135	100	97	94	92	89	86	84	81	79	77	74	72	70	68	65	63	61	59	57	55	53	51	50	48	46	45	43	41	40	38	37	135
140	100	97	95	92	89	87	84	82	79	77	75	73	71	68	66	64	62	60	58	56	55	53	51	49	48	46	44	43	41	40	38	140
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

RELATIVE HUMIDITY TABLE.

TABLE 7.

altered by vitiation and contamination as to be dangerous. The gases important in this connection are discussed below.

Carbon dioxide.—This gas is formed continuously in the body by oxidation of carbohydrates in the tissues. Increasing the oxygen tension has no beneficial effect unless the excess carbon dioxide is removed. The R. Q., or respiratory quotient, is given by the fraction $\frac{CO_2 \text{ produced}}{O_2 \text{ consumed}}$. For normal use this ratio of volume of carbon dioxide produced to volume of oxygen consumed averages 0.82. The normal oxygen consumption per man aboard submarines has been determined to be 0.9 cubic foot per hour, thus the carbon dioxide produced per man per hour may be calculated by 0.9×0.82 or 0.74 cubic foot. Thus a submarine of about 26,000 cubic feet of air space, such as a large S-boat with a crew of 50 men, may safely operate submerged for about 20 hours without releasing oxygen or absorbing carbon dioxide. This may be calculated by the formula $X = 0.04 \frac{C}{N}$ where X is number of hours submerged; C is net air space in cubic foot; N is number of men in crew. Further information on the habitability from this point of view may be found in chapter 27, section I, of the Manual of the Bureau of Ships.

Each submarine is equipped with a Higgins-Merriott colorimetric alkaline-phenolphthalein carbon-dioxide indicator. This is very simple to use and all submarine personnel are required to be familiar with its operation.

There are individual variations in tolerance of carbon dioxide, but in general, tensions below 3 percent

cause mild symptoms; between 3 percent and 6 percent cause headache, discomfort, and deep breathing; between 6 and 9 percent cause extreme distress, panting, and collapse; above 9 percent is rapidly fatal. Particularly if flooding for escape is contemplated, it is of vital importance that as much carbon dioxide as possible be eliminated from the atmosphere. For, as is the case with oxygen, *the physiologic effect of the carbon dioxide is in direct proportion to its partial pressure* (which is a function of the percentage and the pressure in terms of atmosphere).

The removal of carbon dioxide is accomplished by the use of the "CO_2 absorbent," which is spread in mattress covers when necessary. The complete description of the method of testing for carbon dioxide and the use of the absorbent also is contained in the Manual of the Bureau of Ships.

Oxygen.—Oxygen is a colorless, odorless gas which constitutes 20.93 percent of the atmosphere. It is physiologically necessary for life and should not be allowed to fall below 17 percent. Inasmuch as carbon dioxide is produced as oxygen is consumed, there is usually ample warning of oxygen lack, simply by evidence of the increase of carbon dioxide. The classical symptoms of anoxemia are weakness, vertigo, cyanosis, nausea, and collapse. However, oxygen deficiency usually gives no warning, and collapse may be the first symptom, noted. No test for oxygen tension is provided in submarines. However, the approximate oxygen percentage of the air in any given compartment, as altered by respiration, can be found by multiplying the carbon dioxide content by 1.22 and subtracting this figure from 20.93. A practical indication of the amount of

oxygen in the air is obtained by striking a match. If the wooden part of the match will not burn, lack of oxygen is at or beyond the danger limit. Oxygen cylinders are provided in each compartment on board a submarine and oxygen is "bled" into the boat as follows: Sufficient oxygen is released from the cylinder to cause a drop in the gage pressure of the cylinder in pounds per man equal to 13.23 divided by the net capacity of the cylinder in cubic feet. This is repeated every hour. Thus, if the volume of the cylinder is 1.53 cubic feet and initial pressure at 1,800 pounds, for "S" class submarines with a crew of 43 men, oxygen should be released until the pressure in the cylinder drops $\frac{13.23}{1.53} \times 43 = 372$ pounds, or until the gage reads 1,428 pounds. If the new type oxygen-reducer valves are installed, the low-pressure valve should be adjusted so that the hand on the metering gage is set at the number of men for which oxygen is being supplied.

During the flooding of a compartment preparatory to a "lung" escape, the partial pressure of gases will increase, i. e., at a depth of 165 feet, or 6 atmospheres absolute, the oxygen content by volume would still be about 20 percent, but the partial pressure would be increased six times, thereby exerting the physiological effect on the body of 1⅕ atmospheres of pure oxygen. The prolonged breathing of this concentration may be dangerous, therefore the oxygen content before flooding should not be greater than 20 percent.

Hydrogen.—Hydrogen is a colorless, odorless, physiologically harmless, but chemically active gas. An air mixture containing 4.1 percent of hydrogen is inflammable, percentages higher than this may be explosive.

Hydrogen in a submarine is produced by electrolysis within the storage batteries, particularly during charging.

A separate ventilating system is provided for the batteries and the air is discharged outboard during surface runs and inboard during submerged runs. Each battery compartment contains a hydrogen detector for determining the percentage of hydrogen in the air of the system. Three percent is the greatest amount of hydrogen permissible in the battery ventilating system.

Chlorine.—This gas is produced in a submarine when sea water comes in contact with the sulfuric acid in the batteries. It is two and a half times heavier than air and remains close to the deck unless disturbed by air currents. It is highly toxic. A concentration of 1 part per million causes coughing; 10 parts per million is dangerous if breathed for half an hour; and 100 parts per million may be fatal if breathed even for a few minutes. The submarine escape appliance, if properly used, will protect against chlorine.

Carbon monoxide.—This gas results from the incomplete combustion of any kind of fuel and is a constituent of the exhaust gases of engines. It is also found after fires or explosions in closed compartments where there is an insufficient supply of oxygen to afford complete combustion. This gas, even if present in concentrations of only 1 part in 10,000, combines with the hemoglobin of the blood to form a stable compound, which will not carry oxygen to the tissues. Carbon monoxide is particularly dangerous because it is odorless, and those exposed to it are often unaware of any ill effects until they collapse. If the presence of this gas is suspected in a compartment, no one should enter unless wearing

the "lung" provided with a hopcalite canister filter. Complete discussion of this procedure is beyond the scope of this volume, but additional information is contained in the Bureau of Ships pamphlet entitled, "Submarine Safety—Respiration and Rescue Devices," which is available to all submarines.

Ozone.—This gas, present in minute amounts around all electrical machines in operation, is generated in appreciable amounts by ultraviolet lamps. Thus if ultraviolet bacteriological lamps are added to the present ventilative installation of any submarine, due precautions should be observed. Ozone is toxic even in a concentration of 0.04 part per million, causing respiratory irritation and pulmonary edema. The presence of ozone can usually be detected by its characteristics odor. Fortunately, recent tests have shown that it does not constitute a hazard in submarines because it is very active chemically, oxidizing metals, rubber, paint, etc., and thus becoming rapidly decomposed.

Tobacco smoke.—This presents a real hazard in the submerged submarine. The effects are those due to the nicotine absorbed by the body; to odor, particularly of stale smoke; and to irritation of the eyes and respiratory tract. The presence of appreciable amounts of carbon monoxide accompanying the smoke has been under investigation. Without discussing the familiar toxic symptoms of salivation, nausea, impending sweat, and a feeling of exhaustion and palpitation, it should be pointed out that tolerance for tobacco varies greatly, and the young individuals are more susceptible than adults. Some individuals appear to be allergic to tobacco smoke.

Although the acquisition of tolerance protects against unpleasant symptoms within limits, it is certain that the

smoke in the rebreathed air of the enclosed space will exert its full harmful effect upon personnel not habituated to the usage of tobacco. It follows that *under these conditions* the usage of tobacco should be forbidden.

Submarine experience indicates that habitual smokers may be somewhat distressed for a day or two, but that they can adapt themselves without hardship to a routine that permits smoking only where ventilation is adequate.

Apart from its inherently toxic effect tobacco smoke, by virtue of its accelerative influence on pulse rate, acts as a complicating variable to confuse estimates of cardiovascular fitness and response to deleterious environment expressed in terms of pulse rate.

Bacteriology of the Air.

Due to the confined living quarters and the peculiar ventilating problems of submarines necessitating rebreathing of the air, contact and air-borne infections may become significant.

Studies on the bacteriology of submarine air reveal bacteria in considerable numbers. *Staphylococcus albus* is the predominant organism, originating probably in large part from human skin and hair. Streptococcal forms from the throat and respiratory tract are also found, as are gram-negative bacilli, molds, and other forms in small numbers. These bacteria are apparently not present in greater amount than in the living quarters of surface craft such as destroyers. Prolonged periods of submergence do not seem to cause an accumulation of bacteria in the air in greater numbers than are found while operating on the surface. Dust counts are apt to be low but the same organisms have been recovered from sweepings as from cultures of air samples. Comparisons of dust and bacterial counts

suggest that most air bacteria are present on dust particles stirred up by air currents caused by human activity. The relative humidity of submarine air is usually high enough to cause dampness on the decks and uninsulated surfaces. This may have the effect of laying dust particles and thereby reducing bacterial counts. The presence of numerous oil droplets in the air of certain compartments may also assist in this process. Analysis of the water of condensation collected from the coils of the dehumidifier reveals a nearly sterile water, which would tend to exclude the washing-out effect of dehumidification as a possible mechanism in reducing the number of bacteria in submarine air. The effect of battery gases on air-borne bacteria is as yet undecided, but there appears to be no lowering of bacterial counts during the time batteries are being charged. Records of extended war patrols reveal that outbreaks of colds and other respiratory infections are apt to occur early in a cruise, with relatively good health in the ensuing weeks. This indicates the prompt spread of the introduced infection and its subsidence after equilibrium is established with the infecting organism, since no new infecting agents are introduced. However otitis externa and trichophytosis, caused by fungi, may persist because of the high temperature and humidity. Control measures under consideration for the prevention of the spread of respiratory infection on submarines include ultraviolet irradiation of the air, the use of germicidal vapors or "aerosols," such as propylene glycol, and detention periods for the crew before embarking on patrol. This last method might prove impractical, but throat cultures a few days before sailing would prevent trouble by providing for the elimina-

tion of carriers of group A streptococci, diphtheria bacilli, and epidemic types of meningococci.

DIET.

Because of the unusual living conditions on a submarine, the limited food storage space available, and the length of wartime patrols, careful selection and preparation of the food for submarine crews assumes special importance. Fresh fruit and vegetables in sufficient quantity to last longer than a few weeks cannot be carried; therefore, canned fruit, fruit juices, and vegetables, as well as various dehydrated products, must be included in the supplies. Because they conserve space, dehydrated foods are highly desirable and have recently been made very palatable. In all cases it is best to carry boned meat to reduce the weight and storage space required. The major part of this should be beef. A good supply of powdered milk should always be on hand.

In addition to the regular diet, all submarines are provided with multiple-vitamin capsules, each capsule containing one-half the daily vitamin requirement (see p. 50). The pharmacist's mate is directed to issue these vitamin capsules to the crew during patrols at the rate of one capsule per man per day.

Associated with the problem of diet is the ever-present one of constipation among the submarine crew. Improper eating habits, the small amount of roughage available in the diet, insufficiency of fresh fruits, movement of the ship, and the irregularity of meals and sleep all contribute to this difficulty. In addition, the "head" is difficult to operate. A new type that flushes into a central tank rather than overboard with each opera-

tion has been installed on some of the larger submarines. It is desirable that the intake of starchy foods such as bread, potatoes, rice, cornbread, biscuits, and hominy grits be reduced and some of the following be served and eaten at least once daily: Prunes, apricots, apples, figs, raisins, fruit salad, or high roughage vegetables.

Noise.

It has been demonstrated that long-continued exposure to the noise of Diesel engines leads to permanent loss of auditory acuity. In addition to such actual loss, the noise and confinement have a deleterious effect on the nervous system and general well-being of the men, increasing nervous tension and fatigue. Further quieting of submarine engines is desirable and the wearing of ear defenders is being investigated.

Medical Department.

Since the maintenance of the health and well-being of submarine crews is a specialized problem, the medical department representative charged with this responsibility should be an especially qualified man. The pharmacist's mate assigned to a submarine is a picked "independent duty" man and his duties are manifold. He not only takes care of the general medical department activities, i. e., care of the sick, first aid, and care of the injured, transfer of those beyond the scope of his care to shore or tender activities, but he also has numerous routine ship's company duties assigned to him. He issues the vitamins and stimulants (as, for example, to the lookouts exposed to inclement weather for long periods) and supervises the daily treatment

of all of the crew and officers with the ultraviolet "sun" lamp carried in submarines.

Personnel Selection.

In view of the foregoing considerations, the mechanical complexity of the submarine, the cramped living conditions which necessitate close personal contact among the crew, and the fact that each member of the crew must be able to handle more than one job, it becomes obvious that careful selection is necessary to make sure that the men entering the submarine service are in good health and are temperamentally fit for this special duty. The physical standards set forth in paragraph 1535 of the Manual of the Medical Department of the U. S. Navy are high and their purpose is to eliminate all those individuals with any chronic disease (upper respiratory infections, gastritis, venereal disease, etc.) or who are otherwise physically unfit for this duty. In addition to fundamentally good health, it is necessary that the men be qualified on the basis of their level of intelligence and emotional stability. This is accomplished by administering mental tests for the determination of intelligence quotient and by conducting neuropsychiatric examinations. These tests have been found to furnish valuable data to supplement the purely physical picture. In cramped quarters, in overheated, damp air, away from natural daylight and sunshine, the close contact for long periods of time makes intolerable those mental and emotional defects which would otherwise cause no trouble.

Supplemental examinations are employed to determine physical and mental ability to operate special submarine devices, particularly soundgear.

Chapter XVIII

DEEP-SEA DIVING

The prevention of compressed-air illness depends upon the elimination of nitrogen absorbed during ex-

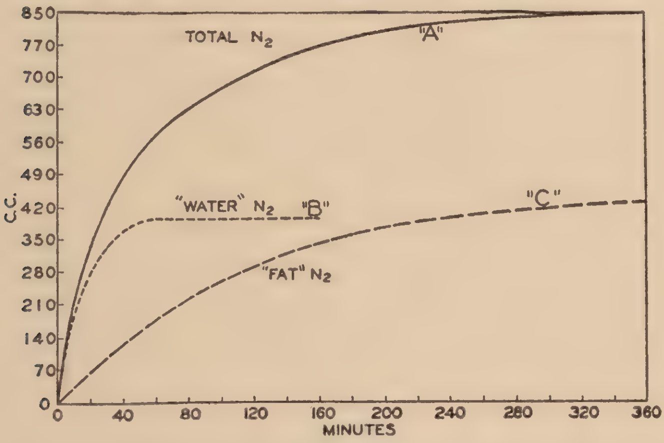

Figure 37.—Solid line shows nitrogen elimination from a young lean man weighing about 60 kilograms. The nitrogen in the body is soluble in fat and fluids. The elimination or absorption of this nitrogen with changes in barometric pressure is represented by the hypothetical, broken-line curves on the graph. (Am. J. Physiol., 114: 138, 1935.)

posure to increased barometric pressure without allowing it to cause excessive bubble formation in the blood stream.

From figure 37 it is observed that about 75 percent of the total body nitrogen is eliminated at a compara-

tively rapid rate and hence does not usually contribute to the formation of bends. There appears to be, however, a relatively small amount of gas in the fatty bone marrow that requires many hours for proper elimination.

At a depth of 90 feet, for example, 10.5 hours of air decompression were required following a 9-hour exposure (probable saturation). On the other hand, a 2-hour exposure (75 percent saturation) at the same depth required only 59 minutes for decompression (table 8). Nine and one-half hours were therefore required for the dissipation of the remaining excess gas amounting to but 25 percent of the total present in the body tissues.

TABLE 8.—*Chamber decompression following prolonged exposure in compressed air*

Simulated depth (feet)	Exposure time (hours)	Decompression time (minutes)	Remarks
30	12	1	No symptoms.
38	5	1.5	Do.
38	7	1.5	Do.
38	9	1.5	Bends 3 hours following decompression.
38	9	1.5	No symptoms. Oxygen 6 hours at surface.
38	12	1.5	Bends 2.5 hours following decompression.
38	12	1.5	No symptoms. Oxygen 6 hours at surface.
60	6	(air) 69	No symptoms.
60	12	(air) 237	Bends 10.5 hours following decompression.
60	12	(air) 311	No symptoms.
Diver C.			
60	12	(O_2) 79	Oxygen 2.2 hours at surface. No symptoms.
60	12	(O_2) 79	Oxygen 4.3 hours at surface, bends 5 hours following decompression.
Diver S.			
90	2	(air) 59	No symptoms.
90	6	(air) 310	Do.
90	9	(air) 458	Bends 2 hours following decompression.
90	9	(air) 583	Bends 1 hour following decompression.
90	9	(air) 638	No symptoms.

From our point of view the body may be compared with a mixture of water and fatty material contained in a beaker. Of the fat an important fraction is sur-

rounded by bone representing marrow and spinal cord substance. This bone-contained fat may be considered as lying in the bottom of the beaker.

If the contents of the beaker are now exposed to a high nitrogen pressure for a short period of time and then quickly returned to atmospheric pressure, diffusion of the nitrogen will take place from the water into the surrounding air and also into the unsaturated water and fat. Following short exposures the partially saturated fat appears to act as a buffer against bubble evolution. By contrast, after long exposures the large reservoir of nitrogen in the saturated fat constitutes the predisposing cause to embolism. The nitrogen within the bone, moreover, will require many hours for removal.

With reference to the matter of tolerance for abrupt reductions in pressure, the body may be exposed to a compression of 4 atmospheres for a period of 27 minutes followed by a rapid decompression to the normal level in 2 minutes. A period of 90 minutes, however, at the same pressure and followed by the same period of decompression would prove fatal.

The nitrogen absorbed in the early part of decompression and presumably dissolved in the body fluids is therefore readily eliminated by any method of decompression. In the rapid drop from 4 to 1 atmosphere, a degree of supersaturation appears to be tolerated by the body approaching a ratio of 4 to 1. By contrast, when the body is saturated at a pressure of 4 atmospheres, requiring a saturation period of 9 to 12 hours, a ratio indicative of supersaturation of only 1.2 to 1 will not hold throughout the whole period of decompression.

Furthermore, during rapid decompression in the low-

pressure chamber, apparent ratios between the pressure of gas in the body and the ambient pressure of 3 to 1 or even 4 to 1 exist, i. e., 1 atmosphere to 0.33 atmosphere or to 0.25 atmosphere.

On the basis of these facts the degree to which the body appears to hold gas in a state of supersaturation is *relative* and depends not only upon the degree of saturation but also upon the pressure level.

Application of physiologic principles.—The important consideration is not mastery of a method of computing the decompression table on the basis of a ratio but rather the acquisition of an understanding of the *basic* physiologic principles, of which one of the most important is the realization of the difficulty in getting excess nitrogen out of fatty tissue, especially bone marrow.

From the point of view of field practice this difficulty has been overcome by progressively limiting the time of exposure in compressed air as the working pressure is increased. The New York State tables (table 9) represent the culmination of this type of experience.

TABLE 9.—*Pressure shifts and intervals of work for each 24-hour period (New York State tables)*

Pressure		Hours			
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Minimum number of pounds	Maximum number of pounds	Maximum total	Maximum first shift in compressed air	Minimum rest interval in open air	Maximum second shift in compressed air
Normal	18	8	4	½	4
18	26	6	3	1	3
26	33	4	2	2	2
33	38	3	1½	3	1½
38	43	2	1	4	1
43	48	1½	¾	5	¾
48	50	1	½	6	½

Value of helium-oxygen mixtures.—Since the objection to long exposures lies in the difficulty of eliminating the gas dissolved in fatty substance, the employment of helium with its low solubility-coefficient in fat would appear to be ideal.

In diving tests, following short exposures in the compressed helium-oxygen or air atmosphere, the body fluids are well saturated with either gas and no particular advantage in decompression accrues from the use of helium (table 10). Following long exposures, decompression time may be reduced as much as 75 percent. Part of the reduction in decompression time is brought about by the inhalation of oxygen at the lower decompression stops, but the important factor is the lessened uptake of helium by fat.

TABLE 10.—*Comparison of total decompression time following exposure in compressed air and exposure in a helium-oxygen atmosphere.*

Depth (feet)	Exposure (minutes)	Decompression (minutes)	
		Air	Helium-oxygen
90	100	50	75
90	180	--------	77
90	360	--------	79
90	540	638	79
150	80	141	121
150	180	--------	126
150	360	--------	128
200	65	217	154
200	90	--------	164

In altitude-test runs oxygen inhalation for a period of 5 hours is required under certain conditions to prevent aero-embolism. If the body nitrogen be removed and helium substituted, the time for oxygen

inhalation can be reduced to at least 90 minutes or a reduction of 70 percent.

In deep-sea diving, exposures are usually short and the advantage derived from helium is that it renders unimportant the narcotic effect of nitrogen as demonstrated in the U. S. S. *Squalus* salvage operations.

Value of oxygen.—Essentially oxygen inhalation permits the elimination of an inert gas at a maximum pressure head as shown by the graph (fig. 37), and at a pressure level sufficiently high to prevent injury from massive bubble evolution.

During the past 3 years the Navy has used oxygen routinely in helium-oxygen diving during the latter part of the decompression period, beginning at the 60-foot level.

In air diving the British have had a great deal of experience with oxygen inhalation and the reader is referred to the book, "Deep Diving and Submarine Operations," by Robert H. Davis. A reduction in decompression time of about 40 percent is effected by the employment of oxygen according to British experience.

The data in table 8 demonstrate the value of oxygen inhalation following decompression at the surface level. Thus the depth could be increased from 33 to 38 feet provided that oxygen was inhaled following abrupt decompression to the surface.

The conclusions drawn from these tests are that a considerable reduction in decompression time is brought about by oxygen. On the other hand, the occurrence of bends following a period of oxygen inhalation of 90 minutes during the initial stage of decompression demonstrates again the difficulty in getting rid of the com-

paratively small residual fraction of nitrogen in slowly desaturating tissue (bone marrow).

Oxygen inhalation undoubtedly serves its best purpose in preventing the serious symptoms of compressed air illness, and its chief value lies in clearing the blood stream and body fluids of the excess nitrogen.

Danger of too rapid ascent to the first stop.—The tendency in diving is to bring men too rapidly to the first stop, which usually is at one-half the depth compared with the original level. This procedure leads to the initiation of the bubble state in the early part of decompression when the pressure head of gas in the tissues is highest.

Symptoms indicative of embolism have appeared during helium-oxygen diving at depths of 180 and 90 feet on two occasions following too rapid ascent from depths in excess of 300 feet. At present for helium-oxygen diving the rate of ascent is limited to 25 feet per minute and an arbitrary period of 7 minutes is taken at the first stop in order to permit the blood to transport to the lungs the large amounts of helium diffusing into the blood stream.

It has been possible to show by actual measurements that too rapid decompression in the early stages leads to an accumulation of gas probably in bubble form so that equal quantities of gas are eliminated during each of the first two 30-minute periods; if the blood stream is not overloaded, about two and one-half times more gas is given off during the first 30-minute period compared with that eliminated during the second period (fig. 37).

In air diving the reduction in rate of ascent to the first stop from 50 to 25 feet per minute greatly reduced the

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incidence of embolism as manifested by the occurrence of pruritus and rash.

Selection of personnel.—A routine physical examination may not be adequate to determine those individuals who are qualified for work in compressed air. One should therefore employ specific *pressure tests* for the selection of fitted men.

With reference to patency of auditory tubes and presumably freedom from infection of the upper portion of the respiratory tract, the immediate application of a pressure of 50 pounds in the chamber will serve to select the qualified men. The assumption is made that the men have previously been instructed in the matter of "clearing their ears." Inspection of the tympanic membrane following the application of pressure reveals the degree of ability to accommodate to excess pressure. Two tests with an interval of several days intervening should be accorded an applicant who is otherwise in good physical condition.

With reference to susceptibility to bends, it follows from a consideration of the physiologic data that the elimination of excess nitrogen without the development of manifest air embolism depends upon effective blood flow through tissues and the absence of excess fat. The desirable type of man is therefore young and lean. Yet among such individuals the variation in susceptibility to compressed air illness makes necessary a specific decompression test for the selection of deep-sea divers.

This test consists in reducing the pressure from 1 atmosphere to 0.20 atmosphere during a period of 7 minutes. Oxygen is inhaled at the start of pressure reduction. The duration of stay in the rarefied atmos-

phere is for a period of 4 hours. Under these conditions susceptible men develop bends while those men who are comparatively immune remain free from symptoms. Six to ten successive daily tests accurately define susceptibility status.

Too much stress cannot be laid on the necessity for the maintenance of good physical condition by men who work in compressed air. Empirical data indicate that any condition tending to impair cardiovascular tone renders men susceptible to the development of decompression embolism. Indulgence in alcohol should be specifically interdicted. Fatigue, infection, hot atmospheres, and excess carbon dioxide in the air are all factors associated with increased incidence of bends. Our deep-sea divers, therefore, maintain a system of training similar to that followed by the athlete.

Summary of principles.—The following principles underlie the prevention of compressed air illness:

1. Limitation of time of exposure in compressed air or the employment of helium-oxygen mixtures for saturation exposures.
2. Reduced rate of ascent in the early stages of decompression.
3. Slow decompression following long exposures and the inhalation of oxygen at the lower decompression levels.
4. Careful selection and the maintenance of personnel in good physical condition.

Treatment of compressed air illness.—The prime requirement in treatment is the rapid restoration of normal blood supply by compression and absorption of the obstructing gas emboli. Behnke and Shaw formulated a procedure of recompression utilizing oxygen, based on laboratory experiments, and later Yarbrough and Behnke applied the principles to field practice.

Recompression.—Essentially the basis of treatment is prompt recompression and the inhalation of oxygen.

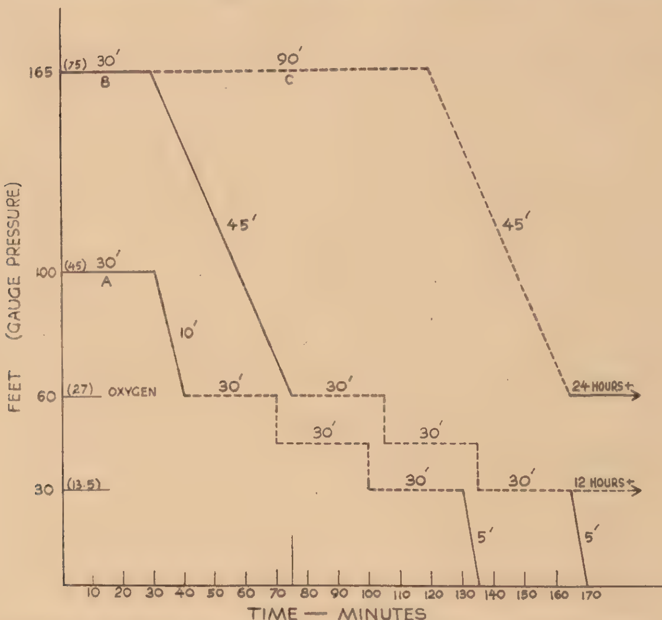


FIGURE 38.—Guide for treatment of compressed-air illness (after Behnke and Shaw, Yarbrough and Behnke).

A—For "bends."
B—For "bends"—asphyxia.
C—For asphyxia/paralysis.

At maximum pressure patient inhales air, or helium-oxygen of about (70 : 30 ratio) mixture.

At 60-foot level or below, patient inhales oxygen for 90-minute period. Attendant inhales oxygen for 30-minute period.

For prolonged recompression at or below 60 feet, air is inhaled.

Figure 38 serves as a guide in the recompression procedure. It is emphasized that the condition of the

patient governs the detailed mode of therapy rather than rigid adherence to a system of tables.

Perhaps there is no therapeutic procedure more effective than recompression as applied to the asphyxiated, pulseless, cyanotic patient whose blood stream is filled with multiple gas emboli. Even patients presenting incipient lesions of the spinal cord have made complete recovery under immediate and prolonged recompression.

In the mild cases of compressed air illness characterized by bends, the minimum pressure applied in recompression is 45 pounds per square inch (gage) equivalent to a diving depth of 100 feet. Relief of symptoms may occur at greatly reduced pressures but the additional compression reduces the size of the bubble 75 percent compared with surface volume, and ensures against the initiation of lesions in the spinal cord.

For the serious cases characterized by asphyxia, probable involvement of the nervous system, or both conditions, recompression is limited to a pressure of 75 pounds (gage) equivalent to a depth of 165 feet. At this pressure the surface size of the bubble has been reduced 83 percent; higher pressures can do little to improve circulation and would unduly delay the pressure at which oxygen could be breathed.

The next stage is the maintenance of the maximum pressure for a period of 30 minutes. Usually this period of time is sufficient to ensure apparently complete recovery, but should paralysis be present or suspected, or if the patient remains unconscious, the maximum pressure is maintained for an additional 90 minutes.

At the maximum pressure, air, or if available, a mixture of helium-oxygen in the ratio of 70 to 30 volumes percent, is inhaled. At the end of the 30-minute period the pressure is decreased uniformly for 40 minutes until the 60-foot level (27 pounds gage) is reached (fig. 38B). If a pressure of 45 pounds has been used (fig. 38A) a period of 10 minutes is sufficient for decompression to the 60-foot level.

Oxygen inhalation is begun at the 60-foot level and continued for a period of 90 minutes until the 30-foot level is attained. If the patient exhibits an idiosyncrasy for oxygen, the usual symptom being nausea, oxygen inhalation is postponed until the 45- or 30-foot levels are attained. Air or the helium-oxygen mixture is inhaled for the period of time at the 60- or 50-foot levels that would otherwise have been devoted to the inhalation of oxygen.

It is unlikely that intolerance for oxygen will exist at the 45- or 30-foot levels and a period of 90 minutes for oxygen inhalation should be feasible for all patients prior to the termination of decompression.

Decompression [1] is then terminated from the 30-foot level by a uniform drop to the normal atmosphere over a period of 5 minutes.

For mild cases of compressed air illness this type of treatment usually affords permanent relief. Should symptoms recur in more seriously injured patients, recompression is again effected to a level between 30 and 60 feet for a period of 12 to 24 hours followed by a gradual return from the 30-foot level to the normal atmosphere during a period of 4 hours.

[1] For the attendant a 30-minute period of oxygen inhalation should ensure adequate decompression.

This practice of prolonged immersion in compressed air colloquially termed "the overnight soak" has proved to be the conclusive method of terminating treatment. The patient is permitted to sleep and the bubbles have adequate time for absorption. Should there be any question of involvement of the central nervous system, the prolonged immersion treatment is routinely put into effect.

For the moribund patient, the pressure level following the 2-hour treatment at a depth equivalent to 165 feet, is decreased to 60 feet during a period of 45 minutes. Oxygen is then administered for 90 minutes, and air inhalation is continued for a period of 24 hours or longer. There should be no hesitancy in continuing treatment at the 60-foot level for a period of days. The increased partial pressure of oxygen at this level is also an effective therapeutic measure in treating the incipient or manifest pulmonary edema, anticipated as a complication of extensive embolism of the pulmonary bed (see fig. 38C).

Adjuncts in treatment are the judicious injection of glucose and saline solutions, or plasma in the severely injured patients in order to counteract the effect of hemoconcentration. The use of epinephrine and the application of warmth (not heat) are additional measures if the shock syndrome is present.

The position of the patient's body should be recumbent since the site of bubble accumulation is influenced by gravity.

Errors in treatment have been:

1. Failure to apply the pressure test in doubtful cases, "It can't be compressed air illness."

2. Delayed recompression. The potential patient avoids the doctor.

3. Failure to keep the moribund patient at the 60-foot level.

4. Failure to keep the "treated" patient near the recompression chamber for a 24-hour period.

Chapter XIX

HYGIENE IN AVIATION

Naval hygiene as it relates to naval flying personnel deals principally with the physical maintenance of officers and men subject to the hazards and physical stresses inherent in their occupation and peculiar to the environment of flying.

Man is by nature a terrestrial animal and whenever he ventures to ascend into the atmospheric envelope surrounding the earth, he finds himself in an environment unfavorable to the carrying on of his normal physiological functions. In the case of the aviator, physiological adjustments must be made to rapidly changing barometric pressures and to extreme ranges of temperature.

Changes in barometric pressure do not alter the composition of the air he breathes, but do alter partial pressures of its constituent gases, and hence the availability of oxygen, and oxygen in sufficient amount is required for all cell life. Above 5,000 feet altitude anoxia begins.

The composition of atmospheric air is:

Oxygen	21 percent	By volume,
Nitrogen	78 percent	
Rare (inert) gases	1 percent	

and is uniform up to an altitude of 70,000 feet. At sea level, air exerts a pressure (weight) of 760 mm. of mer-

cury. Twenty-one percent of this pressure is exerted by oxygen.

Atmospheric pressure (sea level)	=760 mm. Hg.
Partial pressure (oxygen)	=159 mm. Hg.
Atmospheric pressure (10,000 feet)	=506 mm. Hg.
Partial pressure (oxygen)	=105 mm. Hg.
Atmospheric pressure (18,000 feet)	=380 mm. Hg.
Partial pressure (oxygen)	= 79.5 mm. Hg.
Atmospheric pressure (28,000 feet)	=253 mm. Hg.
Partial pressure (oxygen)	= 53 mm. Hg.

The above partial pressures exist only in dry air. They do not exist in the lungs.

	Dry air	*Lungs*
Oxygen	160 mm. Hg.	100 mm. Hg.
Nitrogen	600 mm. Hg.	570 mm. Hg.
Carbon dioxide	Trace	43 mm. Hg.
Water vapor	None	47 mm. Hg.
	760	760

The partial pressures of water vapor and of carbon dioxide remain constant at altitudes considered so far. Regardless of partial pressure of oxygen available in inhaled air, the partial pressures of both carbon dioxide and water vapor must be subtracted in figuring partial pressure of oxygen available to the lungs. Carbon dioxide exists in alveolar sacs in 4 to 6 percent volume and exerts a constant pressure of from 36 to 40 mm. of mercury. Water vapor remains constant at 47 mm.

Increase of altitude (decrease of atmospheric pressure) requires the following considerations:

1. Altitude sickness due to lack of oxygen (anoxia).
2. Effects due to decreased pressures:

(*a*) Decompression sickness ("bends" or "aeroembolism").
(*b*) Expansion of gases in middle ear and sinuses.
(*c*) Oxygen indoctrination and classification.
(*d*) Oxygen apparatus.

3. Effects of temperature.

Contributory stresses in flying are:

1. Blackout—effects of high centrifugal forces due to sudden changes in direction of the plane.
2. Carbon-monoxide intoxication due to exhaust gases from engines or machine guns.
3. The special organs in flying.
4. Conflicting visual and equilibratory stimuli causing "vertigo," sometimes extreme in degree.
5. Unusual motion of plane due to bumpiness and maneuvers causing "motion sickness."
6. Flying fatigue, which is due probably to a summation of all the above stresses plus long hours of intense concentration, working or sitting in constricted spaces, and the continual awareness of hazard.

Aviation hygiene, therefore, must concern itself with these hazards and stresses, their prophylaxis and prevention or amelioration.

Anoxemia (anoxia) arises from a lack of oxygen in the inspired air. The brain is affected before other tissues, with resultant defective judgment, lack of self-criticism, inaccuracy, euphoria, dimming of alertness and impairment of mental processes. Visual acuity is reduced with severe anoxia, and at night the ability to discern dimly illuminated objects is impaired with any degree of oxygen lack. Sensation of weakness in the legs and arms, unsteady gait, inability to coordinate

movements, and finally uncontrollable tremors and twitchings develop with progressive anoxia. This may end in convulsive seizures or simple coma. Lack of oxygen makes the hands and feet cold and may dispose to airsickness. Dizziness, rapid beating of the heart and alternating rapid and slower respirations are frequently seen. The mental changes in the earlier stages are not appreciated by the individual and may prove fatal. *Never risk being short of oxygen under war conditions!*

Oxygen should be used as follows:

1. All flights above 10,000 feet of more than 4 hours' duration.

2. All flights above 12,000 feet of more than 2 hours' duration.

3. All flights above 15,000 feet regardless of the duration.

4. All flights above 23,000 feet at a rapid rate of climb. Undiluted oxygen from the ground up.

5. Pilots are urged to use oxygen equipment whenever practicable, even at low altitudes, in the interests of familiarization and increased efficiency.

At ambient temperature and pressure, gases are in solution in the blood in proportion to their respective absorption coefficients and partial pressures. With slow ascents gases have time to diffuse out through the lungs; but where the ascent is rapid, to great heights and diminished pressure, gases will come out of the blood with the formation of bubbles in vessels and tissues. Considerable variation in susceptibility is noted among flying personnel. In general, slim, physically fit and young individuals appear the least susceptible. Prevention at present consists of classifi-

cation of personnel for altitude tolerance by low-pressure chamber tests.

Characteristic symptoms of aero-embolism:

1. Itching and paresthesias of the skin.

2. Pain in the limbs (muscles and joints) especially in the shoulders and knees. Pain may be mild and relieved by rubbing or movement, or it may become progressively more severe, and even lead to collapse.

3. Abdominal discomfort may be severe from gaseous distention.

4. A vaguely defined generalized discomfort associated with sweating, chilliness and dizziness which may progress to pallor and sudden collapse.

5. Pain behind the sternum and coughing (chokes) occur with less frequency.

All symptoms tend to disappear rapidly when personnel are brought down to the 20,000–25,000 foot levels. Initial symptoms rarely occur below 30,000 feet altitude pressure.

All flying personnel under training should be instructed in the use and functioning of current types of oxygen-breathing equipment and supply. The program of indoctrination should consist briefly of the following:

1. Lectures on atmospheric physics.

2. Demonstration of oxygen supply in low-pressure chamber, proper fitting of oxygen masks and adjustment of service type apparatus.

3. Chamber run:

(*a*) To 18,000 feet without oxygen for 20 minutes. After 15 minutes at this level, a simple pencil and paper code test is given and subjects

are asked to write a brief statement describing how they feel.

(*b*) Oxygen masks are adjusted and ascent made to 28,000 feet at the rate of 5,000 feet per minute. Subjects are held at this level for 30 minutes.

(*c*) Descent at rate of 5,000 feet per minute.

(*d*) Subjects are taught how to clear the eustachian tubes to equalize pressure in the ears, and are impressed with the necessity for slow, regular, normal breathing.

4. Lectures should be given in the chamber by a loudspeaker system during ascents and during stays at the prescribed levels for the purpose of demonstrating the effects of anoxia and the maintenance of efficiency while using oxygen. Lectures can be supplemented by training films during classroom lecture periods.

N. B.—At 25,000 feet individuals last only a few minutes without oxygen; at 20,000 feet from 10 to 20 minutes; at 18,000 feet from 45 to 75 minutes; at 15,000 feet an estimated 5 or 6 hours; at 10,000 feet some pilots can last all day, though with severe after-symptoms of chronic oxygen starvation.

Oxygen Breathing Apparatus.

Rebreather equipment.—Figure 40 illustrates diagrammatically the component parts and functioning of the M. S. A. individual oxygen supply type of rebreather.

Figure 41 diagrammatically illustrates the component parts and functioning of the M. S. A. central oxygen supply type of rebreather.

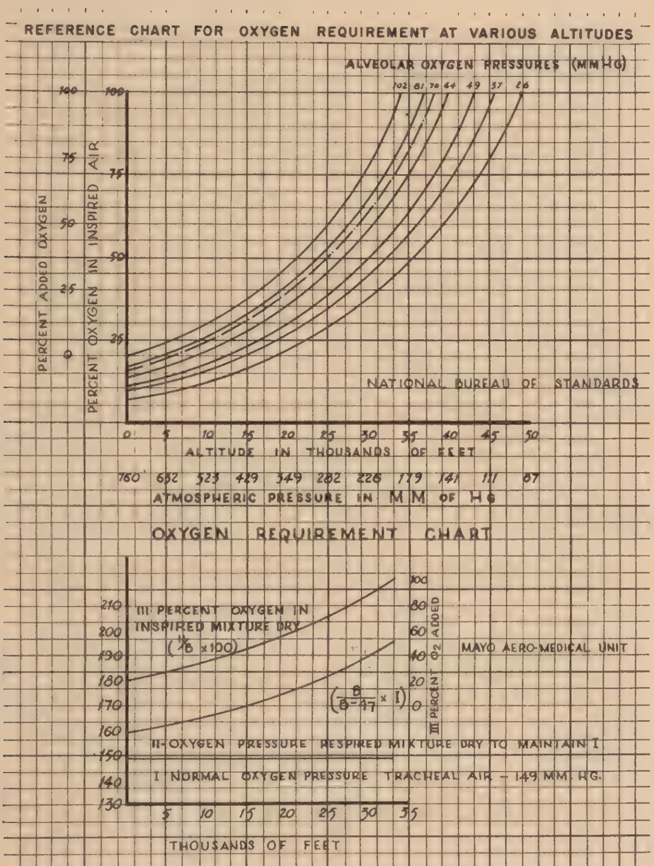
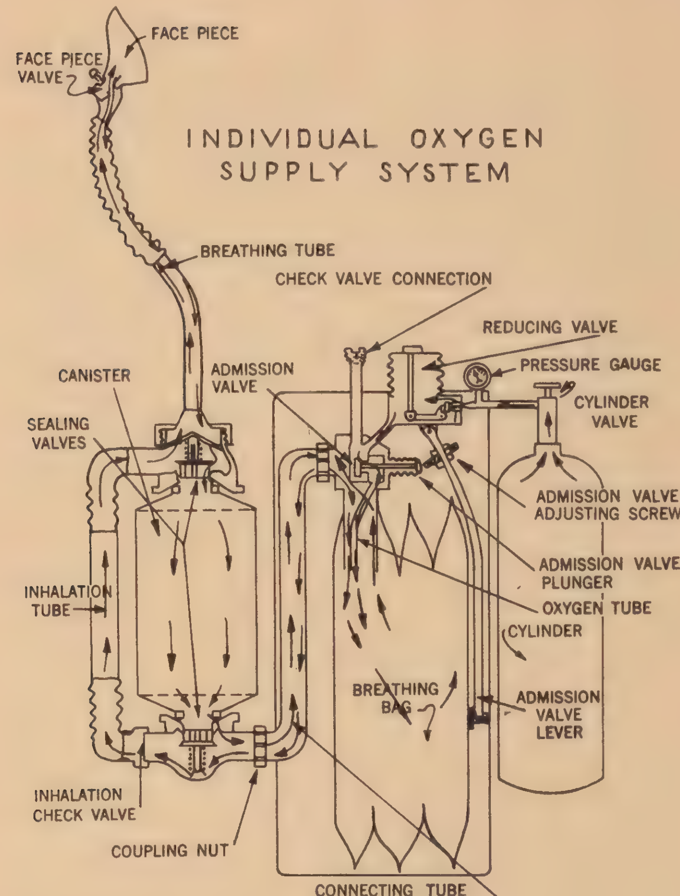

REFERENCE CHART FOR OXYGEN REQUIREMENT AT VARIOUS ALTITUDES
ALVEOLAR OXYGEN PRESSURES (MM HG)
102 81 70 64 49 37 26
PERCENT ADDED OXYGEN
100 75 50 25 0
PERCENT OXYGEN IN INSPIRED AIR
100 75 50 25
NATIONAL BUREAU OF STANDARDS
0 5 10 15 20 25 30 35 40 45 50
ALTITUDE IN THOUSANDS OF FEET
760 652 523 429 349 282 226 179 141 111 87
ATMOSPHERIC PRESSURE IN MM OF HG
OXYGEN REQUIREMENT CHART
210 200 190 180 170 160 150 140 130
III PERCENT OXYGEN IN INSPIRED MIXTURE DRY
(II/B x100)
(B/(B-47) x I)
100 80 60 40 20 0
III PERCENT O2 ADDED
MAYO AERO-MEDICAL UNIT
II-OXYGEN PRESSURE RESPIRED MIXTURE DRY TO MAINTAIN I
I NORMAL OXYGEN PRESSURE TRACHEAL AIR – 149 MM. HG.
5 10 15 20 25 30 35
THOUSANDS OF FEET

FIGURE 39.



FLOW DIAGRAM

FIGURE 40

Figure 42 illustrates the component parts and method of installation of the central oxygen supply type of rebreather in two-place aircraft.

Demand equipment.—Figure 43 illustrates the component parts and functioning of the M. S. A. demand oxygen supply equipment.

Detailed instructions regarding the installation and operation of both rebreather and demand types of equipment are contained in a manual supplied by the manufacturer.

TEMPERATURE.—With ascent, the temperature falls approximately 2° C. for every 1,000 feet until 35,000 feet is reached. Then it remains nearly constant at −55° C. Local variations of temperature do occur.

Protection against cold.—The temperature of the body is maintained by a balance between the heat produced by muscular activity and the heat lost from the skin by conduction, convection and evaporation of sweat, and moisture lost from the lungs. Factors affecting the heat lost from the skin are temperature of the air, wind, and moisture in the air.

The effects of cold on personnel may be briefly stated to be discomfort, *marked loss of efficiency* due to gradual numbing of physical and mental activity. In the case of severe and prolonged cold, this terminates in an uncontrollable desire to go to sleep.

Local intense cold may cause frostbite. Cold may produce spasms of the small arteries leading to reduction of the blood flow and pain. The blood flow may fall below that necessary to keep the tissues alive, especially where there is a concurrent lack of oxygen. When vessel walls are damaged through oxygen lack, serum passes into the tissues and the part becomes

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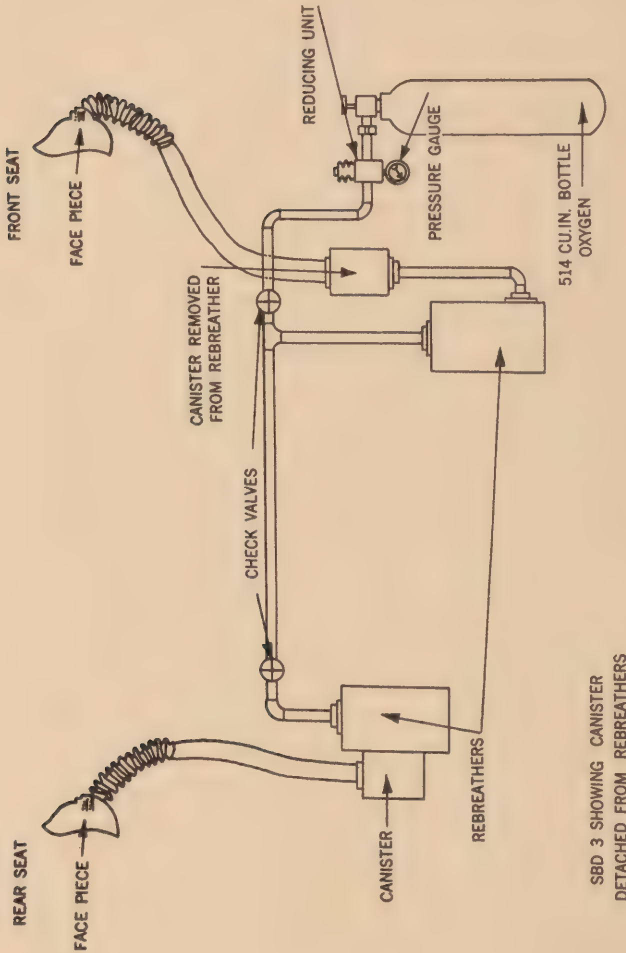
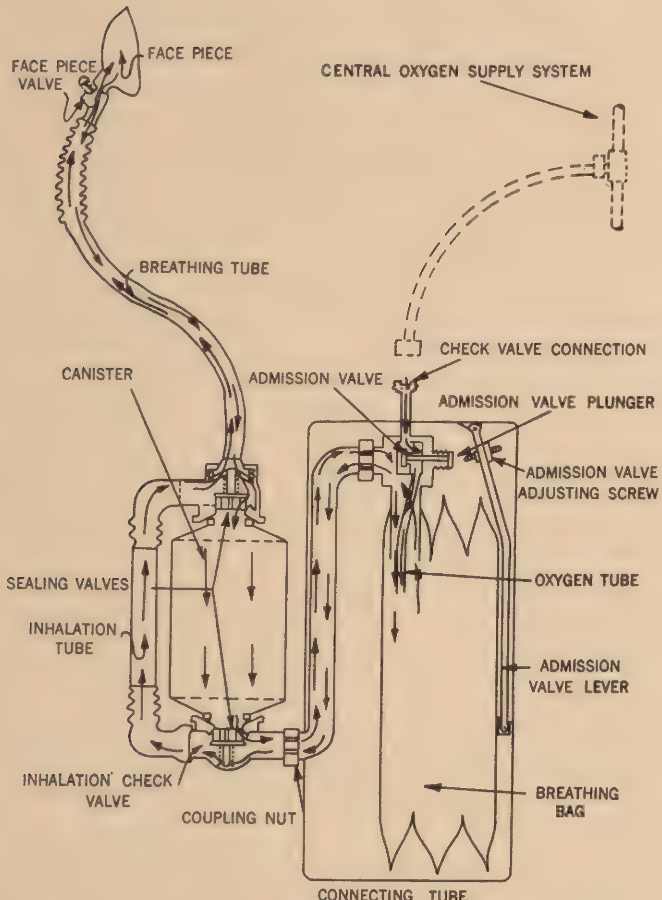

FRONT SEAT
FACE PIECE
REDUCING UNIT
PRESSURE GAUGE
514 CU.IN. BOTTLE
OXYGEN
CANISTER REMOVED
FROM REBREATHER
CHECK VALVES
REAR SEAT
FACE PIECE
CANISTER
REBREATHERS
SBD 3 SHOWING CANISTER
DETACHED FROM REBREATHERS

FIGURE 41.



FLOW DIAGRAM

FIGURE 42.

swollen, blue, and may have blister formation. This may lead to tissue destruction (ulceration and gangrene).

The imminence of frostbite is indicated when the part feels cold. This is usually followed by pain and finally by the loss of sensation (numbness).

Various protective and preventive measures may be adopted to increase the comfort and thereby the efficiency of personnel:

1. Much progress has been made in providing closed aircraft free from draughts, insulated against cold, and with heating arrangement. In general the bow, dorsal turret, belly turret and tail turret are the locations in which subjective cold is most apt to be complained of in larger aircraft. Pilots, co-pilots and radio operators are affected to a lesser degree. There is little evidence that fighter pilots suffer to any degree, and the incidence of frostbite in this group is low.

2. Clothing (see chapter VI).

(*a*) Flying clothing should be windproof, made of material that will absorb moisture from the skin, and that will contain as much air as possible. Efficient flying clothing takes into consideration the fact that stationary dry air is a poor conductor of heat and that application of this fact can be brought about by the use of multiple layers or by furs.

(*b*) Clothing should be loose fitting, especially socks and gloves; otherwise tightness impairs circulation and predisposes to frostbite. Gloves are particularly important to gunners, since some of their tasks require considerable manual dexterity and sense of touch, i. e., reloading guns and ammunition, or changing the bulb

in the reflector sight. Silk gloves may be used if such work is not too prolonged.

(*c*) The importance of dry clothing cannot be overstated. Moist clothing will not only conduct the heat away from the skin readily, but may freeze and become hard and uncomfortable. The body constantly gives off moisture in the form of perspiration; hence it is important that flying clothing should be worn only while flying, and that adequate arangements should be made for thorough drying after wearing. Personnel should not be permitted to spend long periods standing by in ready rooms wearing full flight equipment.

(*d*) The hands and feet should be thoroughly dried before donning socks and gloves. Moist, clammy hands and feet are rapidly affected by cold. The use of ointments to protect against frostbite is not advised. They do afford some protection against heat loss, but are messy, spoil the clothes, and prevent the absorption of moisture.

(*e*) Lack of oxygen is a factor in the production of frostbite. The early symptom is a feeling of cold in the hands and feet; accordingly it is wise always to take oxygen at 10,000 feet or above.

(*f*) The personnel should always be furnished with a hot meal and hot drinks before a long flight. Frequent small amounts of sugary foods and drinks help ward off effects of cold and promote maximum efficiency.

Prevention entails the above-noted precautions; in addition, air crews should wear two pairs of gloves (inner pair silk) and keep numb parts moving. It is reemphasized that *personnel should have thoroughly dry, warm socks and gloves, and dry hands and feet*

before taking off in operational work exposing them to cold.

Treatment of frostbite.

1. Do not put part near any heat.
2. Restore circulation by *gentle* rubbing. (Do not rub with snow.)
3. Give extra oxygen at ground level.
4. If severe—

    (*a*) Elevate the part to avoid venous congestion and to put at rest.

    (*b*) Aseptic dressings *loosely* bandaged.

    (*c*) Use oxygen. (Suggested 8 liters per minute for 1 hour every 2 hours.)

5. Never use vigorous massage or rubbing. Such treatment further damages the part and is dangerous.

Acceleration.—Blackout. The most severe effects of linear acceleration are experienced under the following conditions:

1. Catapult shots.
2. Crashes or crash landings.
3. Rapid deceleration caused by engaging arresting gear in carrier landings.

These forces act on the pilot in one direction, and in the catapult and carrier landings are of the order of from 2 to 4 G (centrifugal force) acting through 2 to 3 seconds. These forces do not cause any great physiological disturbance because they occur in the transverse axis of the body and have little effect on the column of circulating blood. Where crashes through the barriers erected on carriers occur, the forces exerted on the plane and pilot probably do not in most cases

exceed 10 to 12 G. If occupants of planes have proper belt and shoulder harness support, injuries to head and face are in a degree prevented.

In the action of centrifugal force on aircraft and pilots, any aircraft flying along any curve of a circle, whether produced by pulling out of a dive, a tight turn, a diving spiral or any combination of fighter aerobatics, has acting upon it from the center of the circle a centrifugal acceleration which varies directly as the square of the linear velocity and inversely as the radius of the circle. Weight is a force, and is expressed as the product of mass times acceleration due to gravity. Hence when a pilot has acting upon him an acceleration of several times that of gravity, his weight increases in the same proportion. At a centrifugal acceleration of 6 G, a pilot weighing normally 150 pounds would weigh 900 pounds.

The production of blackout is caused by centrifugal forces acting in the direction of the long axis of the body. If these forces are large (over 3.5 G), they are capable of causing pooling or accumulation of the circulating blood in the veins and capillary beds of dependent portions of the body, particularly in the vascular beds of the upper and lower extremities. This acts to prevent sufficient return flow by the venous system to permit adequate filling of the heart chambers. Hydrostatic pressures of the blood column ascending to supply the brain, retinal membrane of the eye, etc., falls to a level at which adequate blood supply to these structures can no longer be maintained. This is due to:

1. Direct effect of "G" on the column of blood from the left ventricle to the head.

2. Inefficiency of the heart as a pumping mechanism due to pooling of blood in the extremities, with resultant inadequate venous return flow to the heart.

When the effects of these circulatory changes reach a given value for the individual pilot, failure of vision or "blackout" occurs. The time taken to reach this point is a function of the individual's physiological mechanism. (A pilot may not blackout when pulling out of a dive if 6 G be applied for 1 second; but would blackout in a tight turn in which 6 G was maintained for 5 seconds.)

For each individual, in order to produce blackout, the minimum centrifugal force exerted for a minimum period of time appears to be 4.5 to 5.0 G acting for 4 seconds.

Unconsciousness is more readily induced by tight and inefficient abdominal belts, by compression of the veins of the neck in a mistaken effort to obstruct the drainage of blood from the brain, by severe degrees of anoxia, and by the after-effects of illness, alcohol or nicotine poisoning. Consciousness returns when the centrifugal force (G) is removed, but the pilot may still have visual loss for 1 to 2 seconds, and may still be markedly confused, with some loss of orientation in space. The best means at present available for the prevention of blackout from high acceleration have been adopted by foreign nations, i.e., Great Britain and Germany. The method essentially consists of the assumption by the pilot of a crouching position which reduces the height of the blood column between the brain and the heart. At the same time the legs are raised as far as possible by auxiliary rudder pedals which elevate the feet about 6 inches, thereby decreasing the venous level between

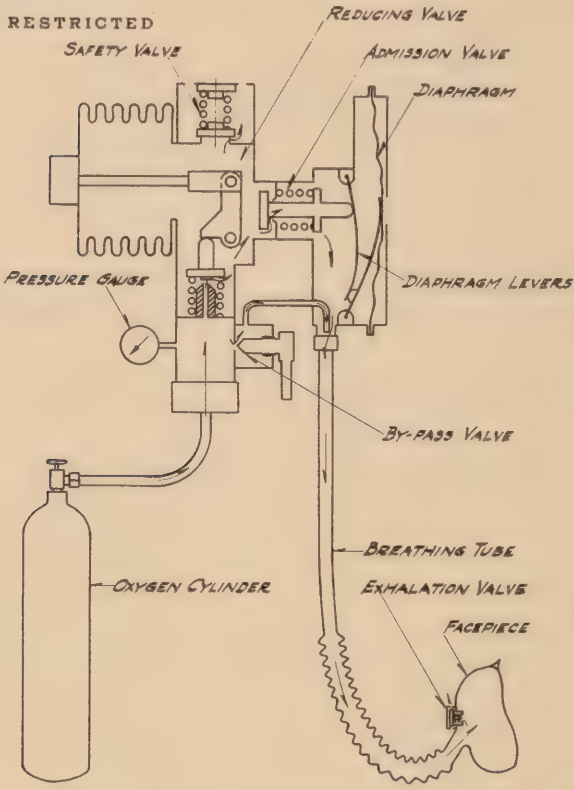
the legs and heart. Assumption of this attitude causes tensing of the abdominal muscles, which can be further accentuated by shouting or straining to increase intra-abdominal pressure and help to prevent pooling of blood in abdominal organs.

All flying personnel should keep physicaly fit, practice exercises to increase abdominal muscular tone, avoid excesses in the use of alcohol and tobacco and refrain from aerobatics until an hour after a meal. Experience has indicated that a full stomach lowers resistance to blackout.

Mechanical equipment designed to assist the venous return flow to the heart has been under study for a considerable period of time. This procedure shows some promise of allowing pilots to withstand higher G values without blackout while in the normally assumed posture in the cockpit.

Toxic gases.—Carbon monoxide is considered the most dangerous of all the gases likely to be encountered in aircraft. In flight, the air stream along the fuselage often produces decreased pressures within so that gases tend to be sucked in. An aircraft engine gives off about 34 cubic feet of exhaust gas per second with high carbon-monoxide content, and it should be remembered that higher concentrations are produced when engines are cold and when there is incomplete combustion operating at altitudes. The known affinity of hemoglobin for carbon monoxide and the resulting stable compound carbon monoxide-hemoglobin seriously lowers the ceiling of personnel even though the percentages of carbon monoxide breathed may appear relatively small. As an example, at 12,000 feet blood oxygen saturation is about 85 percent; breathing 0.02 percent carbon monoxide for an

hour reduces oxygen saturation to 77 percent and in four hours to 65 percent. Such a decrease in oxygen satura-



SCHEMATIC FLOW DIAGRAM
DEMAND TYPE OXYGEN REGULATOR
FIGURE 43.

tion may lead to severe altitude sickness at this level. This danger is lessened but not entirely eliminated while

wearing oxygen masks. Up to 20,000 feet there is danger of carbon-monoxide absorption, particularly in those systems using air diluter demand.

Permissible levels of carbon monoxide in aircraft are:

	Percent
United States (Navy specification)	1.01
British	.005
German	.0025

The symptoms shown on figure 44 are exaggerated with altitude because of lowered oxygen partial pressures.

Oil vapors from the engines may produce nausea and gastric irritation. Potentially, the lead content in exhaust gas may cause lead poisoning, but the danger is negligible compared with the effects and dangers of carbon monoxide.

The Special Sense Organs in Flight.—The most important of the special sense organs for flying personnel is the eye. Good vision is essential to recognition of objectives from great heights, recognition of opponents in the air at a distance, and in the estimation of the possibility of landing on unprepared fields. While flying in sight of the earth, use of the eyes allows correct orientation in space, and while blind flying observation of instruments gives correct objective estimation of the position in the air, the ability to make good landings depends, in part, on ocular muscle balance which can be disturbed temporarily by fatigue or illness. Color perception is essential as long as navigation lights are red and green. Color defectives show diminished perception when fatigued or when anoxic, and under decreased illumination.

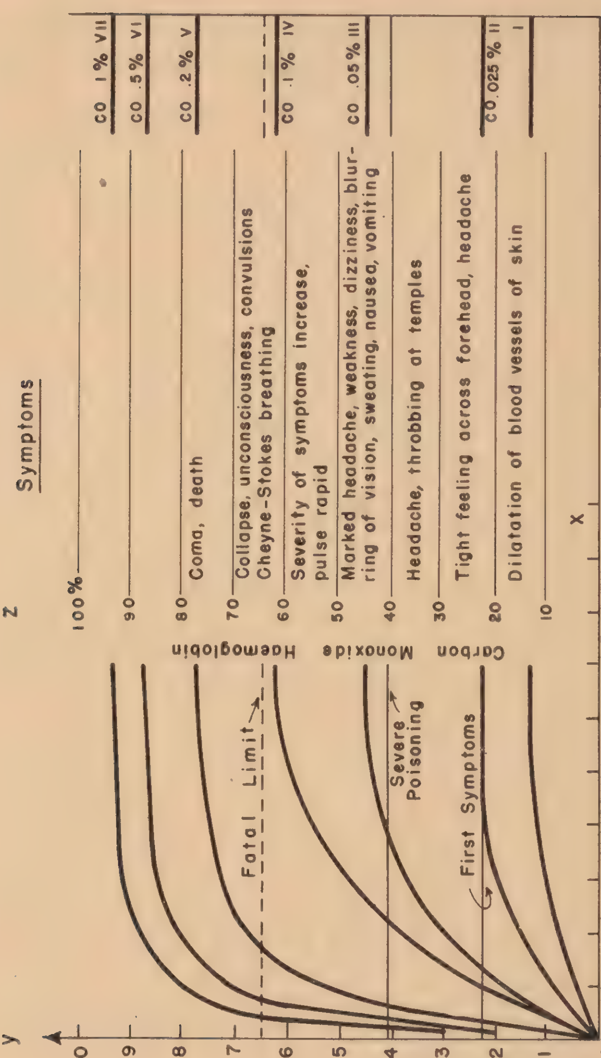


FIGURE 44.—Symptoms accompanying varying carbon monoxide levels.

NIGHT VISION.—One of the most important functions of the eye in war time is the ability to "see" at night. The cones are primarily concerned with day vision, while the rods, on the other hand, are concerned largely with seeing under dim illumination.

This function is brought into play by retinal adaptive process which in the main consists of a chemical change occurring in the rods increasing their sensitivity. Ordinarily this change requires about 30 minutes in complete darkness until the rods reach near maximum sensitivity. The rods are most sensitive at about 510 millimicrons, i. e., to light which appears blue-green to the cones; however, they are relatively insensitive to waves longer than 600 millimicrons. At this point the cones see red and the rods are in the dark up to certain intensities of illumination. Taking advantage of this latter fact, goggles are used which transmit light at the 600-millimicron level and permit visual tasks to be carried out, while at the same time allowing the rods to become almost completely dark adapted (3 to 6 minutes for complete adaptation).

The subject is of such importance that the fundamental rules which aid in securing maximal night visual efficiency are quoted:

1. Do not attempt night duties until dark adapted—avoid short cuts.

2. Maintain maximum dark adaptation by avoiding all possible light, except red light of low intensity.

3. For instrument lighting use dim red light, and do not stare at lighted instruments.

4. Keep windshield and goggles spotless and unscratched.

5. Practice using the "corners of the eyes"—night targets are better seen by not looking directly at them.

6. Move the eyes frequently; practice systematic scanning; be alert for moving objects.

7. Know the tactical value of low light contrast in night missions.

8. Use night binoculars when possible.

9. Observe technical orders in use of oxygen—be overconscientious at night, not overconfident.

10. Don't "break training," the stakes are too high.

11. Learn location of instruments and controls in aircraft by sense of touch. This blindfold drill will pay dividends.

Glare and use of goggles.—The use of goggles is important in maintaining the efficiency of flying personnel, particularly when used to reduce glare, to protect the eyes from irritation by draughts and dust, and to prevent fire or flash injuries. Glare coming from the sun, reflected from water or clouds or from searchlights, induces ocular fatigue and markedly impairs efficiency. Tinted lenses in goggles or spectacles are of great help in reducing glare. The wearing of polarized lenses is not advised, since high velocity air pressure sets up invisible lines of stress in plastics used in windshields which become visible and disturbing when viewed through such lenses.

Effects of altitude on ears and sinuses.—Changes in pressure set up differentials between the middle ear and the external atmosphere which are equalized normally by way of the eustachian tube. With sudden pressure changes, any blockage of this tube, either by mechanical means or inflammatory processes, gives rise

to discomfort or severe pain, or even rupture of the tympanum.

Prevention of discomfort or pain can be avoided by—

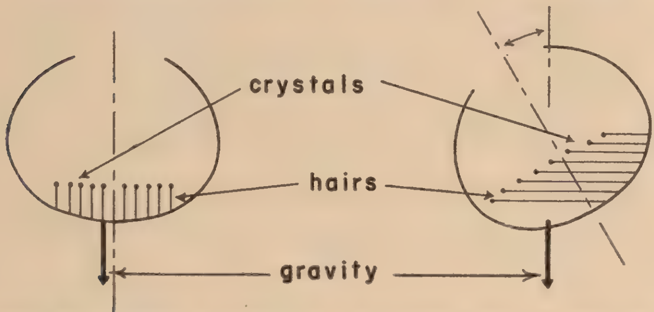


FIGURE 45.—Diagram to indicate how the static organ in the ear is affected by changes in the position of the head.

1. Swallowing repeatedly, yawning, or by pinching the nostrils closed and attempting to blow through the nose.

2. If no relief is obtained, ascent of 1,000 or 2,000 feet and repetition of the methods given above.

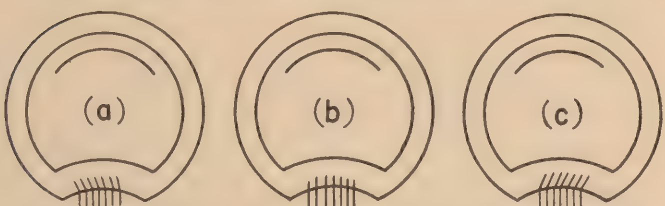


FIGURE 46.—Diagram to show the action of a semicircular canal.

3. Flights to altitude and descents should not be attempted by personnel suffering from sore throat, head cold, or catarrh, unless required by operational necessity.

4. Temporary loss of auditory acuity may be noted after descent, but with equalization of pressure, this soon disappears.

The frontal and maxillary sinuses may occasion severe discomfort if their ducts become blocked. Pressure within these sinuses usually equalizes readily with that of the outside air unless there is mechanical blockage (fractures), or blockage from acute or chronic inflammation.

The use of a benzedrine inhaler (not more than once in an hour) or of a mild vasoconstrictor nasal spray will do much to prevent symptoms.

Equilibrium.—Vertigo, defined as "dizziness or swimming of the head, giddiness; a disturbance in which objects, though stationary, appear to move in various directions, and the person affected finds it difficult to maintain correct posture," is of considerable importance to flying personnel. It is vitally important that the physical and psychological reactions resulting from these sensory illusions be recognized and understood.

The organs of equilibrium are located in the inner ear and consist of—

1. The static organs, for perception of the direction of the pull of gravity and probably of acceleration.

2. The semicircular canals for the perception of movements of rotation.

When the force of gravity and centrifugal force come into play during flight, it is the resultant of these two forces which affects the sensory hairs of the static

organ. This may deceive the pilot as to his relative position in space during instrument flight.

1. At the commencement of rotation, the fluid lags, the sensory hairs are bent back and the brain senses a turning movement.

2. The rotation continues at the same speed and the fluid is now moving as rapidly as the canals; the sensory hairs are upright and no turning movement is felt, although a turn is being made.

3. The rotation has ceased, but the fluid continues moving in the same direction for a time; the hairs are bent in this direction and the brain senses a false turning movement.

Man, with his eyes closed, has no means of sensing a uniform turning movement; but can only sense acceleration or deceleration of the movement. It is therefore possible to rotate a person slowly without his being aware of it.

The organs of equilibrium are closely connected to the eyes by nerve paths. This gives rise to false conceptions in flight due to the fact that the ear organs react to the resultant of gravitational and centrifugal forces, while the eyes react to what they see as well as to nerve impulses from the ear. Consequently, it frequently happens, in flying, that sensations sent by the ear are in opposition to those sent by the eyes and to those sensibilities located in the skin, muscles, tendons, and joints. These opposed impulses received by the brain, and the confused and contradictory directions sent from the brain to the body are considered to be the chief cause of vertigo.

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Blind flying and sensory illusions.—The following are some of the sensory illusions which may be noted during instrument flying:

1. During a steep turn centrifugal force may produce a sensation of ascent. (Pilot's reaction—push controls forward.)

2. Returning to level flight from a steep turn, the removal of the strain of centrifugal force from the body leads to a feeling of less than normal weight and a sensation that the aircraft is falling (Pilot's reaction—pull back on the controls).

3. Where an aircraft skids in a turn, the sensation is that of a tilt opposed to the direction of the true turn.

4. In instrument flying a false sensation of turning often occurs in straight and level flight. This may be due to—

(a) The eyes working in conjunction with the ears and receiving false sensations from the latter.

(b) False sensation of rotation produced in the inner ear when motions caused by turbulent air are recorded.

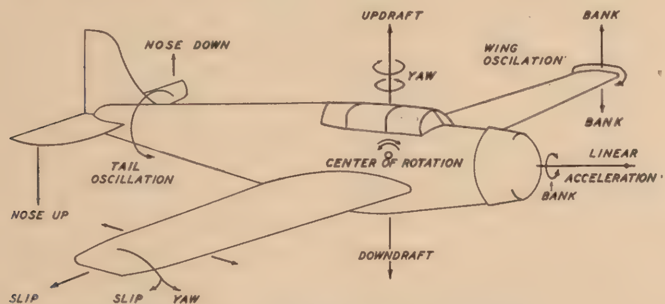
(c) Correction of the course for propeller torque by the rudder, which frequently gives a sense of turning.

5. During a sharp turn, movement of the head often leads to the feeling that the aircraft is diving or tipping; and during a spin the sensation of going beyond the vertical. (Pilot reaction—pull back on controls).

6. Pilots are apparently more subject to vertigo when nervous, tired, or tense. Occurrence among wing men in formation flying is common under conditions of reduced visibility. It is caused possibly by the lack of horizon

or plane of reference, or the skidding and maneuvering necessary to maintain position. The most common sensations are of diving, approaching a stall, or flying in some unusual position, and the pilot's reaction is to recover from whatever attitude he feels he may be in, correction usually resulting in a vertical spin or dive, and often in a fatal crash.

A good general rule for flying personnel to remember is: "The sensations will deceive, but the instruments tell the truth."



DIRECTION OF ACCELERATIONS OF AIRPLANE DURING LEVEL FLIGHT

FIGURE 47.

AIRSICKNESS (Motion Sickness).—Airsickness in personnel is due to an abnormal individual susceptibility to the following factors:

1. Overstimulation of the mechanism of equilibrium with reflex involvement of the vegetative nerve centers of the body.

2. Vertical, rotary, and lateral motion caused by air turbulence and aerodynamic qualities of aircraft.

The primary activating factor in the production of airsickness is vertical linear acceleration, and of lesser

importance, the rotary acceleration around the transverse axis of the aircraft.

The factors causing airsickness, in the order of their importance are:

1. Motion.
2. Loss of visual reference.
3. Odors, vibration, and noise.
4. Cold.
5. Fear or anxiety.

The symptoms chiefly affecting personnel are nausea, vomiting, cold perspiration, weakness, dizziness, and, in extreme cases, marked prostration.

These factors are of importance in that they detract considerably from the efficiency of air crews on war missions. Airsickness may be of extreme importance when flights of air-borne troops either in aircraft or gliders are assigned missions requiring maximum efficiency.

Treatment.—Taking into consideration the causative factors, the best treatment is prevention. The use of drugs to prevent airsickness is not recommended. There is considerable evidence that air crews adapt themselves in some measure as flying experience increases. This factor should be stressed.

Flying Fatigue.—Flying fatigue is a condition resulting from abnormal strain or stresses being placed upon a normal individual. It is found particularly in members of combat crews engaged in combat missions, and affects pilots and air crews alike.

The characteristics of flying fatigue are various and variable, but in every case there are sufficient signs or symptoms which are likely to be spotted by a good

squadron commander or flight surgeon. If the condition is not recognized early, irreparable harm may be done to the individual, and he may be permanently lost as a member of the combat unit. It is of prime importance that there be close liaison between flight and squadron commanders and squadron medical officers in order that early recognition of the condition may be facilitated.

There are stresses peculiar to flying in peacetime which are both physiological and psychological. The former are connected with many conditions including oxygen shortage at altitudes, exposure to cold and fatigue on long flights, and the effects of G involved in certain maneuvers. The psychological strains are those inherent in the pursuit of any duty carrying with it risks which call for constant care and concentration in their avoidance. In peacetime the majority of personnel adapt themselves satisfactorily to these forms of stress.

In time of war the stresses become enormously increased in both intensity and duration, and the effects become cumulative, owing to *lack of opportunity for adequate recuperation*. Once the individual has reached the limits of his endurance, his deterioration is rapid. Physiological and psychological strains react upon one another to establish a vicious circle, which, if not broken early, will inevitably lead to accident or breakdown. The importance of avoiding wastage of personnel by extra vigilance in watching for signs of deterioration and by the application of appropriate countermeasures is obvious. The development of even minor indications of fatigue or stress should be regarded as a danger

signal which warrants close attention and investigation.

The warning signals which are of importance are:

1. *Falling off in flying efficiency.*

2. Markedly increased liability to fatigue, both mental and physical.

3 Loss of interest, disinclination for effort.

4. Increased indulgence in alcohol and/or tobacco.

5. A tendency to become unsociable or irritable.

6. Emotional crises, loss of self control.

7. Physical symptoms such as *loss of appetite*, *inability to sleep properly* (nightmares frequent), *loss of weight*, the presence of tremors, tachycardia, and typical anxiety facies.

The occurrence of the symptoms may be the only evidence of what may be termed a "preneurotic state" for which a period of rest, leave, or change of duty is indicated.

Prevention is of primary fundamental importance in handling the problem. Briefly outlined below are some of the methods which may be applied in order to avoid personnel wastage.

1. Institution as far as possible of recreational facilities aboard operating stations. This should include aircraft carriers insofar as practicable, the attempt being to provide some degree of relaxation and relief from constant routine.

2. Every effort should be made to provide as great an amount of comfortable sleep as possible for personnel who are required to fly.

3. Leave should be granted freely whenever possible, consistent with operational requirements.

(*a*) For shore-based operational squadrons, a 24-hour leave in each week or after any major operation; at least 8 days every 6 weeks or 14 days leave in any given 3-month period.

(*b*) Carriers—It is difficult, if not impossible, to stipulate any definite program of leave for carrier-based squadrons. Where possible, personnel should always be granted leave to the fullest extent when the carrier is at anchor. This leave should be clear of the ship and not on the basis of a 1- or 2-hour recall. Such leave on a restricted standby status defeats its own purpose.

4. There is no apparent necessity to set arbitrary operational flying limits for personnel. However, foreign experience has indicated that signs of incipient fatigue among personnel are first noted around 100–125 hours for fighter personnel and 125–150 hours for bomber personnel. Patrol personnel average about 250–300 hours. The above noted hours refer to combat operational flying only. These limits should not be set up arbitrarily as limits for pilot or air-crew efficiency, but rather as a guide to medical officers in their estimations of peak personnel efficiency.

5. Handling of cases of incipient fatigue: Prevention should be as far as possible an administrative problem effected by close cooperation between commanding officers and medical officers. The following factors should be considered:

> (*a*) Placing individuals (with incipient fatigue or stress) on the sick list has a deleterious effect upon individual and squadron morale.

(*b*) Hospitalization under medical care reacts unfavorably as far as the restoration of the individual to peak operational efficiency is concerned.

(*c*) It is unwise to mix cases of incipient fatigue (those presenting more or less intangible evidence of staleness—war weariness) and those cases which have developed well-marked symptomatology with predominant psychogenic aspects. Intermingling the two has a distinctly unfavorable reaction on the incipient cases indicated by a gradual loss of "edge" and desire to return to a full operational status.

(*d*) Rehabilitation should be chiefly recreational or by a change of duty status, either to nonflying duties or by transfer to flying training activities.

(*e*) Do not whip a "tired horse" with drugs. Such a procedure is physiologically unsound and leads to eventual exaggeration of the condition.

Fatigue in high altitude flying.—Flights over 25,000 feet, and especially over 30,000 feet, often produce an exhaustion out of proportion to the duration of the flight or the effort involved. This fatigue appears to be much greater than that experienced in flights of 20,000 feet or below, irrespective of whether the mission involves combat or patrol.

The condition manifests itself in the following manner:

1. A brief period of exhilaration.
2. Loss of interest in surroundings.
3. Feeling of exhaustion. This fatigue tends to be progressive with repeated exposure. Flying efficiency is diminished. Physical findings show little except a slight to moderate diminution of red cell count and hemoglobin.

When pilots or air crews exhibit the signs of fatigue accompanying high altitude flights, they should be granted a short period of leave (6 to 10 days). This will usually restore them to full operational efficiency.

Aircraft accidents.—Advances in military aviation have contributed more to performance and design than to safety factors of aircraft. With this increase in the requirements from the human, there has arisen a correspondingly greater number of accidents which are attributed to personnel failure.

A number of factors may enter into the causes of aviation accidents. Chief of these are—

1. Technical failure (structural, power plant).

2. Personnel failure (pilot error, carelessness, negligence).

3. Weather and terrain (low visibility, storms, icing, rough landing spaces).

By far the greater number of accidents are attributed to personnel failure. The factors contributing to this are briefly outlined below.

1. Anoxia.

   (*a*) Failure of oxygen apparatus due to cold, faulty mechanism.

   (*b*) Faulty functioning due to unfamiliarity with apparatus or lack of knowledge concerning the effects of altitude.

   (*c*) Anoxia due to carbon-monoxide poisoning. (This may be due to technical deficiency of the aircraft or personnel carelessness.)

2. The accentuation of disease or constitutional defects under conditions of high altitude flying (flying following an illness). Also of importance is continued

flying by "stale" or fatigued personnel. These latter factors lead to gross errors of judgment and diminished efficiency.

3. Effects of acceleration: Blackout, particularly in low level dive bombing or in torpedo plane attack may be a fruitful source of accidents with serious injury or fatal termination.

4. Training in all phases of flying and in physiological factors producing reactions in air crews is most important in the prevention of accidents. From the medical standpoint, physiological factors in particular should be stressed. It is insufficient to give preliminary lectures and instruction to personnel while in the training phase only. Indoctrination and instruction should be carried out without interruption in operational units.

Safety appliances.—Apparently it is not possible to avoid injury in those crashes in which the aircraft is completely destroyed, demolished or burned. However, there are a number of accidents in which structural peculiarities or failure to use safety devices contribute to injury. Personnel should be thoroughly indoctrinated in the wisdom of using the shoulder harness, and where that is not available, the thigh straps.

INDUSTRIAL HAZARDS.—There are numerous toxic substances to which ground personnel may be subjected.

Chief among these are airplane dopes, cleaning materials, aviation gasoline, fire-extinguishing compounds, engine exhaust gases, and oil fumes.

Airplane dope.—The hazards from doping are well controlled and personnel engaged in this type of work should suffer no ill consequences if existing regulations

are carried out. From a preventive standpoint, attention to ventilation of workrooms, careful personal hygiene, protective clothing, adequate fresh air and sunshine, careful fire precautions and monthly medical checkups are the most important factors.

The chief danger from *cleaning materials* is from caustic burns or from fire. Carbon tetrachloride is a possible exception. The fumes and liquid of this compound are toxic, and if allowed to come in contact with heated metal, phosgene is formed. Preventive precautions should include the avoidance of breathing vapors or spilling liquid on clothing, keeping material in closed containers, and good ventilation.

Aviation gasoline contains tetraethyl lead, a toxic compound. Precautions should include avoidance of direct contact with the skin or clothing, and of breathing fumes. Where the skin has been contaminated, soap and water will provide adequate cleansing. While handling the fluid, rubber gloves should be worn.

The chief *fire-extinguishing compounds* are carbon dioxide and carbon tetrachloride. Carbon dioxide spray may cause severe burns if blown on the exposed skin, and it is possible that dangerous concentrations may be encountered in small closed spaces. The dangers of carbon tetrachloride have already been noted under cleaning solvents.

Engine exhaust gases are chiefly important from the possibility of carbon-monoxide poisoning. (See previous description.) The main precaution is adequate ventilation when working in enclosed spaces.

Breathing hot *oil fumes* in inadequately ventilated spaces may give rise to upper respiratory irritation, headache, nausea, and vomiting. Very little difficulty

should be experienced if adequate ventilation is provided.

AIRCRAFT EMERGENCY RATION.—The present authorized emergency aircraft ration consists of the following:

Pemmican.
Malted milk tablets.
Sweet chocolate.

Pemmican is packaged in one-fourth-pound cans and consists of the following ingredients:

1. Rendered kidney fat.
2. Prime oleo oil.
3. Seedless raisins.
4. Evaporated apples.
5. Crisp bacon.
6. Peanuts.
7. Dextrose.
8. Shredded coconut.
9. Vanilla extract.
10. Salt.

Three types are furnished: Class I lacks the bacon and peanuts; class II lacks the evaporated apples and peanuts, and class III lacks the evaporated apples and bacon.

The malted milk tablets are supplied in a glass container holding 3 ounces (about 40 tablets).

The sweet chocolate one-fourth-pound bar contains chocolate, sugar, oat flour, milk, vanillin, vitamin B. Caloric value of the cake is 600 calories.

Total caloric content of the ration is 4,000 calories.

Emergency water is supplied in cans, 8 ounces to each can, 3 cans per person.

FIRST-AID KITS.—First-aid kits for pneumatic life rafts are furnished as a single-unit package. Contents of this six-unit package are as follows:

1. Six Syrettes (morphine tartrate).
2. One iodine applicator (bottle type, 10 cc.).
3. Two tubes of burn ointment (tannic acid).
4. Two one-half-inch bandage compresses.
5. Sulfanilamide (for topical application, 5 gm. per packet, 5 packets).

This first-aid kit is supplied for all one-, two-, and three-place aircraft.

A large 10-unit first-aid kit is supplied for long range patrol aircraft carrying larger crews. Contents of this package are:

1. Six morphine Syrettes (morphine tartrate).
2. One iodine applicator (bottle type, 10 cc.).
3. Two tubes burn ointment (tannic acid).
4. One package sulfanilamide powder, five 5-gm. packets.
5. Sulfadiazine (twenty-four 1-gm. tablets).
6. Four 1-inch compresses.
7. One triangular bandage.
8. One web tourniquet.
9. One battle dressing, small.
10. One package scissors, safety pins.

It is quite evident that the contents of the two first-aid kits will not meet all the needs of personnel operating under unusual conditions. However, it is expected that local medical establishments, after determining the needs, will provide supplemental supplies as required.

Duties of medical officers attached to aviation activities.—It is fundamental that a medical officer should thoroughly acquaint himself with the personnel and material of the station or ship to which he is attached. He should know the type or types of aircraft, the number and duties of the crew, seating arrangements, type of heating, endurance, range, ceiling and types of oxygen equipment installed. He should estab-

lish himself as a part of the squadron (or squadrons) and become a part of its administration. He must identify himself with all aspects of squadron life, whether in the crew room, on the sports field, or in operational phases, and he should be available at all times for interview and for requests requiring his special attention. In addition it is necessary that medical officers take part in routine medical duties, including sickbay duties, and in every way assist in cooperation between the Medical Department and commanding officer.

Rest, relaxation and sport.—Recreational activities are highly important as a means of maintaining morale and efficiency. All efforts should be made to secure, as far as possible, 8 hours' sleep out of 24 for operating personnel. During periods of rest (stand-off from operations), idleness or slackness should not be tolerated. The most beneficial form of relaxation from restricted and emotionally toned effort is to be found in exercise of the body and mind in play, and every effort should be made ashore and afloat to provide sports for personnel. Such sports as wrestling, boxing, handball, shuffleboard, etc., are readily adaptable on board ship and allow a considerable range of personal preference to supplement the more diverse activities that can be indulged in ashore.

Chapter XX

FIELD HYGIENE AND SANITATION

It has long been recognized and is an axiom of combat that health of the fighting personnel is essential in war. Preservation and promotion of health of the forces in the field requires attention to a number of details, each trivial in itself.

The Medical Department's authority over field hygiene and sanitation is largely advisory. The quantity and quality of medical care is contingent upon the military situation. Military requirements take precedence over medical care and humanitarian needs. The naval service does not furnish funds, installations or labor for field sanitation, hence care of the health of the individual is largely left to the local command.

Food in the field.—Troops in the field, as a general rule, have limited opportunity to supplement their military rations by purchase from outside sources and thus are unable to supply any deficiencies existing in their food allowance. Hence it is particularly important that the field ration be well balanced as regards to fats, proteins, carbohydrates, and mineral elements and have the required vitamin content.

The daily menu should be prepared at least 24 hours in advance. On the march, or when otherwise engaged in heavy work, troops will have a craving for sweets

and a liberal amount of jam should be provided to satisfy this craving.

The mess gear should be washed in boiling soapy water and rinsed in boiling clear water. Surplus and reserve food supplies should be protected from such insects as flies and roaches, dust, dirt, and rodents.

The weight of vitamin-containing foods of an exclusive military ration should be at least 30 percent of the total.

The field kitchen should be located on the side of the camp opposite the latrines and urinals. Every precaution should be made to protect the food from dust and dirt and, if practicable, the field kitchen should be screened.

If the kitchen has a dirt floor it may be oiled with motor oil to control dust.

The food handlers should be instructed and trained in personal hygiene and cleanliness and should be given a physical examination at regular intervals.

The mess halls, screened if possible, should be located near the kitchen. The mess tables should be cleansed and sunned at regular intervals and care must be taken to prevent the collection of food particles in the cracks of the table. This is usually accomplished by construction of a table with a removable center board.

Care should be taken not to cook the food too long as this tends to destroy some of the vitamins. During the World War I, scurvy broke out in one organization, and without any alteration in the diet the outbreak was arrested immediately by reducing the period of cooking from 6 hours to 45 minutes.

In Mesopotamia, during the World War I, British troops eating white bread suffered from beriberi while

the Indian troops eating bread made of unmilled wheat were unaffected. During the siege of Kut the reverse was the case, the British lived largely on fresh meat while the vegetarian Indians lived largely on white bread.

WATER IN THE FIELD.—As a result of the policy of immunizing naval personnel with the enteric antigens, water-borne diseases have been more or less eliminated. However it is important that water sources be inspected and that sterilization be employed before permitting the drinking of any water from sources that, potentially, may be contaminated. Boiling is the simplest method; however chlorination is the usual method employed.

In the absence of chlorinated lime, tincture of iodine can be used to sterilize water in the canteen or the water sterilizing bag. Two and one-half teaspoonfuls (10 cc.) of 7 percent tincture added to a sterilizing bag (36-gallon capacity) of water will purify it in 30 minutes. Two drops of the tincture added to one canteen of water and allowed to stand for 30 minutes will sterilize the contents.

Chlorinated lime (bleaching powder, calcium hypochlorite) is prepared by saturating slaked lime with chlorine gas. When freshly prepared, chlorinated lime contains about 35 percent of available chlorine.

Grade A calcium hypochlorite includes such preparations as "H.T.H." (high test hypo) and "Perchloron." These compounds are more stable and contain about twice the available chlorine that ordinary calcium hypochlorite contains.

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When added to a bagful of water 1 gram of calcium hypochlorite or one-half gram of "H.T.H." will yield 2.5 parts of free chlorine per million.

The responsibility for the water supply is usually delegated as follows:

(*a*) *The Marine Corps quartermaster or Navy supply officer.*—Procurement of water rights and delivery of water to the camp site.

(*b*) *Medical officer.*—In advisory capacity, for quantity and quality of water supply.

(*c*) *The unit commander.*—For the proper distribution of the water within the command.

HYGIENE OF THE MARCH.—Care of troops on the march is of paramount importance. The men should be trained in marching by gradually increasing the length of the hike and weight of the pack. The most suitable time to start the day's march is 1 hour after break of day. Night marching should be practiced only when military necessity demands, in which case it should begin soon after sunset. Before leaving camp elimination of the sick and physically unfit is necessary. A sanitary detail must see that the camp site is left in a clean condition and, during the march, see that the road rules of sanitation are obeyed.

The men should start the day's march at a slow pace in order to warm up, and the end of the march should be at a similar slow pace in order to enable the men to cool off gradually.

When marches are of considerable length and forced, singing and whistling of popular tunes should be encouraged. Such stimulation tends to prevent exhaustion by distracting the men from their fatigued state.

Straggling must be avoided. Straggling casualties are due largely to preventable foot disorders and their occurrence creates a nail-foot-sock-shoe problem that requires constant attention. The development of losses, organization difficulty, packing of ambulances and futile employment of medical personnel while on the march can be overcome by rigid adherence to sound rules of foot care. Feet should be inspected before and after every march and all minor disorders should be attended to promptly.

March fracture is a fracture of the second or third metatarsal bone at the junction of the anterior and middle thirds. It occurs in marching with heavy load, especially in double time.

New shoes should not be worn on the march unless they have been broken in.

PHYSICS AND PHYSIOLOGY OF THE MARCH.[2]—Compared to the steam engine the human mechanism is a bit more efficient. The engine is capable of utilizing only 13 percent for useful work from its fuel, whereas our body utilizes 20 percent of the energy value of a consumed diet. The 80-percent balance goes into the production of heat which must be dissipated in order to keep the body temperature constant.

A soldier marching 15 miles carrying full equipment, performs 353 foot-tons of work.

According to Haughton, as quoted by Harrington, this labor, in walking over a level surface, is determined by the following formula:

$\frac{(W+W^1)\times D}{2240}$ multiplied by C equals number of foot-tons

[2] After LeLean, P. S., Sanitation in War. P. Blackiston's Son & Co., Philadelphia, Pa.

Where: W equals weight of person.
W' equals weight carried.
D equals distance in feet.
2240 equals number of pounds in long ton.
C equals coefficient of traction.

The coefficient of traction varies for different rates of speed. For 2, 3, 4, and 5 miles per hour, it is approximately $\frac{1}{26}$, $\frac{1}{20}$, $\frac{1}{16}$ and $\frac{1}{14}$, respectively. Thus a man weighing 160 pounds, carrying 40 pounds and walking 15 miles at the rate of 3 miles per hour, will perform an amount of work equivalent to 353.57 foot-tons.

$$\frac{(160+40)\times 79200}{2240} \text{ multiplied by } \frac{1}{20} \text{ equals } 353.57$$

or, if at the rate of 2.5 miles per hour, 307.45 foot-tons. As we know from physics, one kilogram-calorie equals 3,087 foot-pounds or 1.38 foot-tons.

Then 350 foot-tons would require 254 calories or energy as work, but only 20 percent of the calories can be utilized as work, hence the 254 must be increased by 80 percent which will total 1,270 calories.

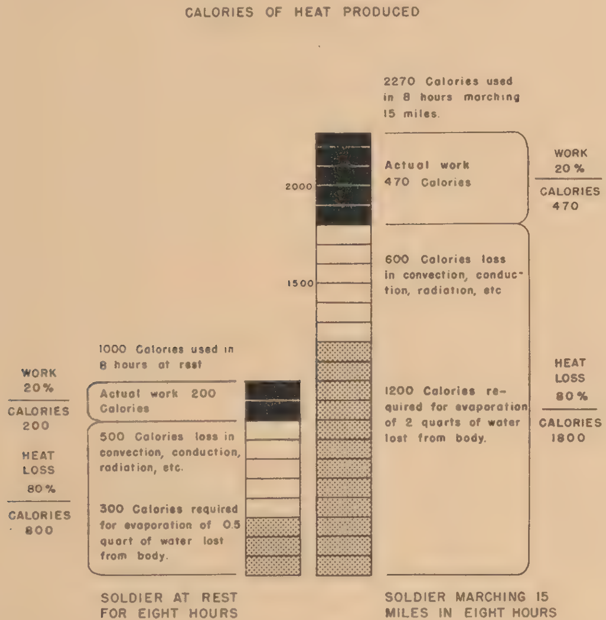
But the soldier in 8 hours normally expends 1,000 calories, so 1,000 plus 1,270 equals 2,270 calories, which will be the food requirements for a man hiking 15 miles in 8 hours. (fig. 48).

Heat dissipation.—The evaporation of water acts in dissipating heat of the body in a fashion analogous to the action of the radiator of the automobile in maintaining the motor near a constant temperature.

The evaporation of 1 cc. of water requires 0.5 calorie, consequently the evaporation of a quart of water

(1,182.52 cc.) from the body's surface will dissipate 600 calories of heat generated by a marching soldier.

Heat equilibrium.—The human mechanism—similar to the automobile motor—must be warmed up before it can function at its best in marching.



ENERGY BALANCE SHEET PER 8 HOURS AT REST AND ON MARCH OF 15 MILES (After LeLean)

FIGURE 48.

The physiological best temperature for the body in marching is 100.5° F., and 102° F. is the maximum temperature before serious symptoms become noticeable such as swaying, tremor, nervousness, etc.

Thus there is only 1.5° range between the optimum body temperature and danger body temperature "and this narrow safety margin indicates alike the delicacy of the adjustment mechanism and the importance of every means of aiding that adjustment."

If the soldier expends 2,270 calories in 8 hours marching 15 miles, 80 percent (1,816 calories) must be lost in dissipating heat.

Of the 1,816 calories, 30 percent is disposed of by radiation, conduction, and convection, while the remaining 70 percent must be disposed of by evaporation of fluids. Since the evaporation of 1 quart of water takes 600 calories, then the total water which must be lost in this 8-hour march is approximately 2 quarts.

CONSERVANCY IN THE FIELD.—Conservancy is a technical name for the collection, removal, and disposal of waste products. As a general rule, while on the march and in temporary camps, burial is the usual method of disposal of waste products; in camps of more or less permanent nature incineration is preferred. In the field, trench latrines, soakage pits, field incinerators, etc., must replace the functions of sewage disposal plants and water-carriage sewage system.

Manure can be taken care of by incineration, chemical treatment, spreading and close-packing (composting or biothermic method).

In the biothermic method, the wetted manure is closely packed in a pile. The fermenting manure will generate a heat of 140° F. to 160° F., while a temperature of 115° is sufficient to destroy the larvae of flies within a few minutes.

At camp sites near the shore on rocky terrain, especially small coral islands, where the surface soil is too shallow to permit trench latrines, short low piers extending into the sea have been satisfactorily used as latrines by military forces. Garbage and refuse are placed in barges, hauled out to sea and dumped.

Camp and bivouac sites.—Before determining the location of a camp or bivouac site a number of military and sanitary factors must be considered. Available sites or areas in the line of march are investigated and reported on by quartering or reconnoitering parties of which a responsible medical department representative is a member. The final decision as to the site to be used is made by organization commanding officers. In the selection of camp and bivouac sites the medical department representative serves as a sanitation expert and in that capacity makes pertinent reports. Such a sanitary survey is an analysis of the conditions existing in a prospective camp or bivouac site which are considered to influence, favorably or unfavorably, the health of the men expected to be quartered there.

The sanitary aspects of a proposed camp site can be given very little, if any, consideration when an organization is moving into combat. All activities devoted to the preservation of the health of the force must then be governed by the military situation.

The method employed in the moving of troops (by foot, mounted, trucks, tractors, planes, etc.) and the nature of the terrain and "road net" over which they are to pass will limit the number of available camp sites. The physical strain which troops might have to undergo to reach a more distant site may be the cause of eliminating an otherwise desirable location.

Because of greater mobility, mounted, mechanized, and air-borne troops may greatly lengthen the daily distance, thereby increasing the number of satisfactory sites, some of which would not be accessible to foot troops.

On the other hand, motorized troops may be confined to the use of highways while foot and mounted troops can be moved over both good and bad roads, over fields and across country. When this occurs foot and mounted troops, although limited by distance, are permitted a wider selection of sites than is available to motorized troops.

The conditions which would be likely to cause and transmit disease among troops must be carefully considered in the selection of a camp site. Taking into careful consideration the sanitary and health conditions of local civil communities, a prospective camp site should be investigated as regards to the following sanitary features:

1. *Water supply.*—An adequate supply of potable water must be available from sources that can be reached, either by the men directly or by animal or motor drawn water carts. All local water used for drinking purposes should be sterilized by boiling or by the use of one of the acceptable chemical methods.

2. *Terrain.*—Ideally, the terrain should be one that permits good drainage during and following rainfall. Therefore flat country overlaid with clay should be avoided. The topography should be rolling and the vegetation, soil, subsoil and first impervious layers of a character that will permit drainage, disposal evacuations and shade conducive to the utmost health and comfort of the men. Troops should not be camped

in the neighborhood of swamps or other water-collecting sites or near rank vegetation, all of which are potential breeding-grounds for insects.

In this connection it is of interest that during field maneuvers in the past, one body of troops selected a camp site near a spring-fed, fresh-water basin in order to be near a good water supply. Within a few weeks 60 percent had reported sick with malaria. Another military force that chose to camp only 2 miles away had a negligible incidence of malaria. It is better to transport water and avoid proximity to anopheles-breeding areas whenever possible.

3. *Civil inhabitants.*—When practicable, a camp site should be located a reasonable distance from a populated area. The necessity of billeting troops, for short or long stays, in the homes and buildings of a community is likely to occur during war. Every effort must be made by the quartering medical representative to obtain full medical intelligence on the public health condition of the population and community in which the troops are to be billeted, and every safeguard must be taken to protect the troops from infectious disease.

In general, the factors to be considered when selecting a suitable camp or bivouac site are:

(*a*) A rolling, well-drained area having a sandy loam or gravel soil for drainage.

(*b*) Availability of an adequate supply of good water and fuel.

(*c*) Grass and shade trees as wind-breaks in cold weather and protection from the sun's rays in summer.

1. Avoid clay or alluvial soil, marshes and insect-breeding places.

2. Avoid base of hill, ravine or dry river bed.

3. Avoid site of recent camp.

Sanitary orders.—In camp or billets, the sanitary and hygienic measures required to protect the health of troops are stipulated in sanitary orders prepared by the senior medical officer and signed by the unit commander. Such orders apply equally to all elements of the force and designate the duties and responsibilities of all personnel. Specifically, a sanitary order applies to the establishment, use, and maintenance of—

1. Food, mess halls, and kitchens.
2. Water supply.
3. Quarters (tents, billets, or barracks).
4. Personnel hygiene (scrub and wash clothes—bathing).
5. Waste disposal (excreta and refuse).
6. Insect control.
7. Sick call (time, location, hospitalization, and evacuation).
8. Venereal disease control.
9. Physical inspection.
10. Civil community.
11. Special measures.

Chapter XXI

ARMORED UNITS

The armored units in the United States Marine Corps consist of tanks and armored amphibian tractors. Duty in these types of vehicles is extremely arduous in that personnel must operate in a confined space with limited visibility, be constantly jolted about, exposed to gaseous fumes and extremes of temperature and humidity. In view of the above conditions it is essential that assigned personnel meet the highest physical standards.

The tactical employment of armored units will frequently result in individual armored vehicles being separated from trained medical personnel. The confined spaces in which the crews of armored vehicles operate make it difficult for medical personnel, even if available, to render first aid promptly. For these reasons the personnel of armored forces should be thoroughly trained in administering first aid.

In many instances injured personnel are required to evacuate a disabled tank without delay. In such cases the first-aid kits are frequently left behind because of the haste with which the tank is evacuated, and are thereafter unavailable for use. By training, and by properly placing the first-aid kit in an easily accessible spot, personnel can be taught to remove the kit automatically during evacuation.

Evacuation of Wounded.

After considerable study by the Armored Force Surgeon and the Armored Force Medical Research Lab-

oratory, the Armored Force Board at Fort Knox, Ky., has adopted certain methods of casualty handling. These methods are adaptable to the existing types of

FIGURE 49.—Front and rear views of pistol belt-suspender method equipment, using one pistol belt and one suspender belt.

armored vehicles in the United States Marine Corps and are as follows:

1. Pistol belt—suspender method.
2. Inversion (feet first) method.
3. Floor hatch method.

THE PISTOL BELT-SUSPENDER METHOD.

This method requires either one pistol belt and one suspender belt, or three pistol belts. The two modifications of this method are described as follows:

(*a*) *Use of one pistol belt and one suspender belt.*—The pistol belt is placed around the waist of the casualty, then the suspender belt is fastened to the pistol belt in the normal manner. If necessary the arms or feet may be securely fastened by means of additional

FIGURE 50.—Front and rear views of pistol belt-suspender method equipment using three pistol belts.

pistol belts. The casualty is then hoisted through any appropriate opening in the vehicle by two men. Suspenders are issued to armored units on the basis of one per individual.

(*b*) *Use of three pistol belts.*—If a suspender belt is not immediately available, one can be improvised from pistol belts. Two pistol belts are adjusted in

such a manner that a loop, of sufficient size to permit a third pistol belt to be threaded through it, is formed

FIGURE 51.—Showing casualty being supported by pistol belt-suspender method. Note use of an additional pistol belt threaded under shoulder straps to provide better mechanical advantage for hoisting crew.

on each end of both belts. This is accomplished by sliding the keeper until a loop of the proper size is

obtained on one end of the belt; the loop at the other end is produced by fastening the small hook normally used to adjust the length of the belt, to the appropriate center eyelet of the belt. A third pistol belt, to be worn

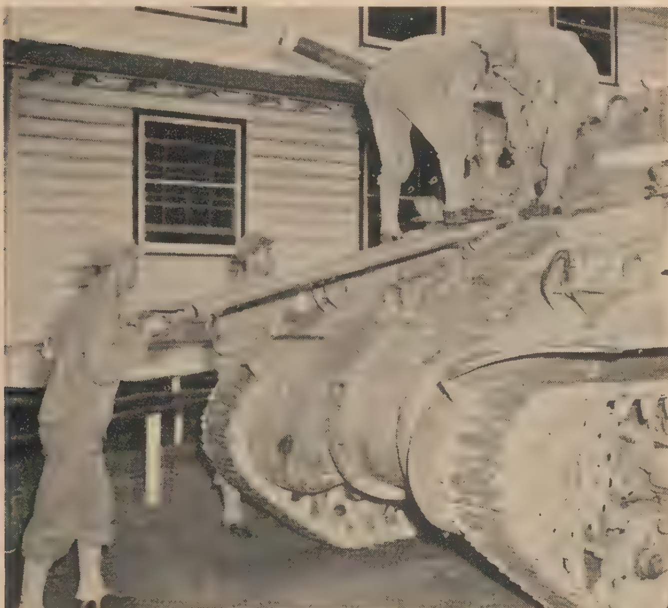


FIGURE 52.—Removing injured from tanks. Showing removal of assistant driver (M4 medium tank) by means of suspender strap-pistol belt method.

around the waist, is threaded through the four loops of the other two belts in such a manner as to produce a belt with suspenders (not crossed). The waist belt is fastened and the casualty then hoisted out through any appropriate opening.

The *advantages* are: No special equipment is required; it is satisfactory for all types of injuries below the hip joint; the method can be used by tank crews without assistance.

The *disadvantage* is that it is not satisfactory for serious wounds of the chest or abdomen.

THE INVERSION (FEET FIRST) METHOD.

This method consists of lifting the man through the nearest hatch or turret opening feet first. A pistol belt, trouser belt or seat safety belt is attached tightly around both ankles below the shoe tops. The man is then laid flat on his back and the feet well elevated toward the opening through which he is to be evacuated. The man standing above grasps the strap and slowly lifts the evacuee out through the hatch, being aided and guided by one man from below who sees to it that the evacuee is not injured as he is lifted upward. Having been removed from the hatch, the evacuee is carefully laid across the bow of the tank until a litter-bearer can assist in removing him to the ground. When the wounded man is in the driver's or bow gunner's seat the transmission housing should be padded by blankets, combat jackets, a couple of gas masks or similar articles to provide a relatively soft bed upon which the man may be laid without danger of burning before the evacuation is completed. In the turret, the man is simply laid flat on the floor and made comfortable with available duffle. With practice, a complete evacuation can be accomplished in less than 2 minutes.

Its *advantages* are: No special equipment is required; it is applicable to all hatches of all existing tank models; it tends to decrease rather than to in-

FIGURE 53.—Showing driver of M4 medium tank in position preparatory to being hoisted through hatch by the inversion method.

crease shock; it has no undesirable effects on major wounds of the head, neck, spine, chest, abdomen, and

FIGURE 54.—Showing driver being hoisted through hatch of M4 medium tank by the inversion method.

pelvis; it can be used in all types of wounds except those involving fractures of both legs; it can be done by the crew members or by medical personnel with

FIGURE 55.—Showing driver of M4 medium tank being laid across bow of tank preparatory to transferring him to a litter.

FIGURE 56.—Showing driver of M4 medium tank being placed on litter.

equal facility; and it can be done with a minimum of two men; three are preferable.

Its *disadvantage* is that this method should not be used when there are fractures of both legs. It is difficult to use when there are fractures of both arms requiring splinting of the arms prior to evacuation. This circumstance prevents evacuation through the bow hatches of modern tanks by any method yet devised. Such personnel should be moved into the turret before evacuation or else should be removed through the floor hatch.

THE FLOOR HATCH METHOD.

In all newer tanks a floor escape is being provided. In most instances it is under and behind the bow gunner's seat. It is approached by removing the bow gunner's seat and then dropping the plate onto the ground.

Evacuation from the bow seats is accomplished feet first by simply lowering the man through the floor hatch, having one man underneath the tank to assist in pulling him out. A litter may be placed beneath the floor hatch and the man evacuated directly onto it.

In order to evacuate a man from the turret compartment through the floor hatch, it is necessary to rotate the turret until its major opening is directly above the floor escape hatch. A litter is then placed under the escape hatch. The evacuee is lowered, preferably head first, from the turret opening down through the floor hatch onto the litter. To accomplish this maneuver without danger of increasing injury three men are required; one in the turret, one in the driver's compartment, and one underneath, to aid in handling the evacuee.

The chief *advantage* of this method is that it can be done under gunfire without unduly exposing personnel

FIGURE 57.—Showing floor hatch method of evacuation in which casualty is lowered head first from the turret of M4 medium tank to a litter located under the tank.

to its danger. It also decreases the physical effort required on the part of evacuation personnel.

It has the *disadvantage* that a considerable amount of manhandling is required to complete the evacuation.

FIGURE 58. Showing evacuation by floor hatch method in which casualty is lowered head first from the turret of M4 medium tank to a litter located under the tank. The casualty is "fed" onto the litter which is slowly being pulled along by one or two men under the tank.

In the presence of gunfire this disadvantage is not sufficiently great to make evacuation impracticable.

GUN FUMES IN TANKS

Fumes from any gun contain ammonia and carbon monoxide. If there are enough fumes in the air to be

FIGURE 59. Showing floor hatch method of evacuation in which casualty is lowered onto a litter placed under the tank.

seen, then men are exposed to carbon monoxide. Ammonia fumes will be very apparent by their effect on the

FIGURE 60.—Showing floor hatch method of evacuation in which casualty is lowered feet first onto a litter placed under the tank.

eyes. After five rounds of 75-mm. rapid fire there may be enough ammonia in the air to cause irritation of the eyes which will interfere with gunnery. Fumes are very much the same from 75 mm., 37 mm., and machine guns, but the 75 mm. is more dangerous.

From the tactical point of view ammonia fumes are very important because they cause tears. Even though the eyes are not irritated it is not safe to assume that carbon monoxide is not present as it is tasteless and odorless. Carbon monoxide accumulates and gradually lowers efficiency.

Normally there is enough cool air swept through the bulkhead oil coolers to keep the air in the tank safe when firing at a slow rate. When firing is rapid or when more than one gun is being fired, then it will be necessary to gun the engine to 1,000 or 1,200 r. p. m. for 15 to 20 seconds or until the air is clear.

If the tank is fought as a pill box, hatch covers should be left open when possible. Ventilation can be increased by cracking the overhead hatches and opening the floor hatches, thereby creating a draft.

Chapter XXII

RECRUIT SELECTION

The process of selecting recruits for the naval service begins at the recruiting stations and is continued through the training period of those who are accepted for enlistment.

The mission of the recruiting service is to insure by careful selection of applicants that those accepted as enlisted men are individuals of high quality. The minimum standards require they should be of good repute in their home communities, possess at least normal intelligence and a reasonably sound education, be physically fit to perform any of the duties to which they may be assigned and possess the mental capacity to assimilate instruction in those duties. The success of this program depends upon the character and efficiency of the recruiting personnel, upon a continuing policy of establishing and maintaining contacts whereby prospects with the desired characteristics will be obtained, and upon thorough investigation and careful physical examination of all applicants prior to acceptance.

The results of the selective recruiting program have been evident to the general public in the high quality of the men who compose the enlisted force of the Navy, and to the service in increased efficiency of enlisted personnel, a higher percentage of reenlistments and a lower incidence of avoidable losses such as by desertion and by discharge for reasons other than expiration of en-

listment. The recruit who can be trained over a period of years to perform the duties and accept the responsibilities of a petty officer is worth two or three who leave after the minimum period of service or who must be discharged for unsuitability. The misfits who must be separated from the service during the first months after enlistment constitute a nuisance, and a hindrance. The time and effort expended in trying to train them has been lost. This could be used better in developing more promising candidates rather than in attempting to correct the errors or in effecting the discharge of those who are readily recognized as inapt for the service.

In addition to meeting the minimum requirements of intelligence, education, and physical fitness, the recruit must possess the constitutional qualities and temperament necessary to adjust himself to service life. He will be called upon to serve under various conditions anywhere the Navy may operate and it will be his duty to assist in the operation and maintenance of the largest and most intricate engineering organization in the world. In time of national emergency the enlisted personnel of the regular Navy who have been well trained in their duties constitute a nucleus upon which the naval forces can be expanded. Under such conditions they will have to assume increased responsibilities and many of them will be advanced to warrant and commissioned rank. It is obvious therefore why the standards for peacetime enlistment must be high and because of this, emphasis is placed on quality rather than on a numerical quota. The general public is acquainted with the high character of the men who compose the enlisted force and it is well known that only the specially qualified are accepted. Through emphasizing that a career in the

service offers specialized technical training, medical care, certain financial return, and retirement benefits after a definite period of service, no difficulty is ordinarily encountered in obtaining the required quota.

There has been no definite educational standard established for recruits although the regulations require that a candidate shall be able to read and write and that he possess a reasonably quick and clear understanding and be able to do a certain amount of elementary arithmetic. The applicants for enlistment are given a modified intelligence test in an endeavor to determine their general mental qualifications for service, to indicate in a broad way what special aptitude they may present and to eliminate the mentally defective. This procedure is known as the group classification test and was first used at the naval training stations where it was introduced in 1923 by the Training Division of the Bureau of Naval Personnel. It proved so valuable in eliminating mental defectives and providing a means for group classification that in 1931 it was introduced at recruiting stations. During peacetime all of the applicants for enlistment are given this test. No man with a mark below 50 can be enlisted as an apprentice seaman although otherwise desirable candidates of this group may be enlisted as steward's mates. The routine use of the test at recruiting stations, during wartime, is impractical because of the greatly increased number of enlistments. Its use under such conditions in the recruiting of enlisted personnel is limited to the study of borderline cases, the major portion of the classification and psychiatric selection of the recruits being carried out at the training stations.

The physical qualifications required to meet enlistment standards have been established in detail and are based on the principles of sound medical judgment as tempered by previous naval experience. As a basic requirement an individual must be free of organic disease, mental illness, and psychopathic traits. The qualifications may be modified from time to time particularly in relation to dental, visual, and height-weight standards as necessitated by the manpower needs of the service. Those men who have defects which are likely to become aggravated during active duty in the Navy, or which are of such nature that they may later be used as the basis for a claim against the Government are not accepted. This policy is dictated by existing legal provisions whereby a person in active naval service who develops aggravation of a disability which existed prior to enlistment then becomes eligible for certain Government benefits. Furthermore it is very important that medical examiners enter all defects (deformities, and sequelae of injuries, operations, or diseases) which are noted at the time of enlistment, on the descriptive sheet and medical history sheets of the health record. This is important because it is generally held that once a member of the naval service has passed the required physical examinations for enlistment, he must thereafter be considered as having been in sound mental and physical condition when accepted, excepting where positive facts are presented showing the disability complained of existed prior to his entrance into the naval service. Thus in the event an individual while in the service becomes disabled because of a condition which would appear to have existed prior to enlistment, it is necessary that actual facts be

presented in order to rebut the legal presumption of soundness at the time of acceptance. It frequently happens that applicants for enlistment are found to present minor defects which are disqualifying for acceptance according to existing standards. The medical officers do not have the authority to either ignore or waive these defects. However, a recommendation may be submitted to the Navy Department for waiver providing the defects are considered not sufficient to disqualify for the performance of duty and are not of a progressive nature or likely to become aggravated by service. The Navy Department policy regarding waiver of such defects is influenced by the fact that certain conditions which may appear insufficient to disqualify for enlistment often become aggravated by service; whereas others are of such nature that the individual may complain of symptoms therefrom in order to avoid undesirable assignments. There are other applicants who present disqualifying defects which are amenable to surgical correction. The medical officers can assume no responsibility, either for themselves or for the Navy, in fitting such applicants for enlistment and are not permitted to operate with a view to qualifying them. Furthermore, no assurance can be given a prospective recruit that he will be enlisted once he has obtained correction of an otherwise disqualifying defect.

There should be no doubt as to the physical fitness of recruits. They must be free from any defect or pathological condition which would interfere with the performance of the duty expected of them in the service, or which would as a result of service be especially liable to undergo progressive change or to become the

basis of a claim against the Government. The examining surgeon must remember that all candidates examined are, unless specifically excepted, enlisted for the performance of all duties pertaining to the naval service ashore or afloat. The individual's condition must be carefully weighed in relation to the duties he may have to perform, inasmuch as candidates for special ratings need not possess the physique and endurance of those actively engaged in strictly military duties. The presence of slight defects in those who have matured or in those who have had previous military or seafaring experience has less significance than in the cases of youthful applicants who have been adjusted to occupations of a more confining and less rigorous character. It is recognized that regardless of the thoroughness of the enlistment examination, some cases with conditions such as asthma, peptic ulcer, glycosuria, so-called orthostatic albuminuria, psoriasis, and the like, because of the periodicity or seasonal nature of such conditions, will be enlisted while symptom-free. These individuals either constitute a potential liability to the Government from a pension or compensation viewpoint or are not physically qualified to perform all of their duties and therefore must be discharged by medical survey at such time as their disabilities are recognized.

It is desirable that the character of the applicant for enlistment be studied carefully and his antecedents and general reputation in the neighborhood inquired into insofar as possible prior to his acceptance. The existence of certain constitutional conditions or of latent mental illness may not be detected because of lack of trained personnel, proper facilities, and the necessary

time to make a complete analysis of the individual's inherent constitutional characteristics and the influence of his past environment and previous training. The formulation of an opinion, however, as to character, personality, ability, and desirability will be greatly aided by a review of the applicant's past history, and school and occupational record obtained from his relatives, neighbors, family physician, and former employers.

At such time as the foregoing procedure has been completed and the applicant's enlistment effected, arrangements are made for his transfer to a training station where he will undergo the regular recruit training program. While such an individual is a potential unit of the service, experience has proved it necessary that he receive detailed clinical, laboratory, and neuropsychiatric study upon arrival at the training station. It has been found advisable to concentrate here the trained personnel, special equipment, and observation wards necessary to detect obscure disease, latent or preclinical mental illness, personality defects, and abnormalities of temperament. The medical examination is rigid and thorough and includes x-ray chest study as an aid in eliminating those with pulmonary tuberculosis or other conditions of such nature as may be of present or future clinical significance; and blood serological study to eliminate those with syphilis. Any physical conditions or defects which may have been overlooked at the recruiting office are searched for and, if found, are recorded. If the disability is of a minor nature its presence is simply noted in the health record, but if it is more serious in nature and not necessarily a cause for rejection, a request for waiver is submitted

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by despatch or letter to the Navy Department. When such conditions are probable or possible causes for rejection the recruit is either kept under observation in a duty status or transferred to a naval hospital for further study and disposition. Those who are obviously disqualified are immediately brought before a Board of Medical Survey with a view to discharge.

It is recognized that incident to enlistment certain military ineffectuals consisting largely of the constitutionally inadequate, some of the borderline mental defectives, and a few preclinical psychotics will escape detection or be able to conceal their condition. This is true because it is often difficult to determine during the time an applicant is under observation in a recruiting office, whether he presents a personality defect or is suffering from or is predisposed to mental disease. The number of such cases enlisted during peacetime recruiting is negligible compared to the number accepted during wartime mobilization. This is understandable when it is realized that peacetime recruiting is conducted by medical officers of the regular Navy who have had long naval experience, are thoroughly familiar with the required standards and cognizant of the difficulty those individuals with psychopathic personalities experience in adjusting to service situations. Furthermore, in peacetime recruiting there are long waiting lists of applicants for enlistment, and only a small percentage, consisting of the most desirable candidates, need be taken. The situation during wartime mobilization is quite different. Much of the recruiting must be carried out by medical personnel only recently called to active duty from civilian life, many of whom have from the

nature of their former occupation had little or no previous naval experience. Furthermore a much higher percentage of applicants must necessarily be accepted, and, as noted previously, it is not practicable under these conditions to give all accepted applicants the group classification test prior to enlistment. Thus during wartime mobilization it has been found necessary to establish special units to detect those who would be a continual handicap through chronic inaptitude and inefficiency or who by breaking down at some critical moment might seriously disrupt the functioning of their entire unit. To meet this need the Navy Department has set up a special organization at each training station. The incoming recruits receive special psychiatric study as a part of their medical examination. This is conducted by a psychiatric unit composed of qualified psychiatrists who are aided by well trained psychologists. Such psychological tests as modern science has shown practicable are used in order to reduce to a minimum the number of unsuitable, inapt, and undesirable individuals introduced into the service. A high percentage of these individuals can be detected by trained personnel in the course of a 3-minute examination, but with borderline cases a period of observation on the psychiatric ward is often necessary, and some require a period of observation under training conditions. At any time during the training period the company commanders may refer backward, poorly adjusted, or seemingly maladapted individuals to this unit for further study and investigation. By analyzing the inherent capacity of the recruits it can be determined whether the material is sufficiently good to work with and also whether there are present,

traits which will make certain phases of naval life difficult or impossible. Such cases as are considered unfit for continuation in the service are referred to a special board for review and recommendation as to disposition. This is known as an aptitude board and functions directly under the commanding officer of the training station. It is composed of line and medical officers of long naval experience, medical officers who are qualified psychiatrists, and a psychologist. The boards are guided by the knowledge that under all-out wartime mobilization a certain percentage of all recruits arriving at naval training stations will prove unsuitable service material. They recognize that the waging of war places a tremendous stress on combat personnel and that those personalities already heavily burdened by anxiety are apt to break under this stress and become disabled by acute anxiety states, confusion, or panic. The prevention of these acute disturbances is important because of their "psychic contagiousness," their tendency to spread through the unit, and the rapidity with which they tend to disable others whose feelings of personal security are threatened from within. This is costly to combat efficiency and precautionary measures are vital. With this in view, therefore, and a detailed psychiatric analysis of such cases available, the aptitude board interviews them and makes appropriate recommendations to the commanding officer of the training station who is authorized to effect the discharge of those individuals considered unsuitable for retention in the naval service.

At such time as those recruits who have been found qualified have completed their regular recruit training

they are transferred to technical schools for vocational training, to the fleet, or to other assignments in the service. It is expected that these individuals when placed in this new environment will be called upon to make certain adjustments. For the most part they have been accustomed in civil life to an existence where strenuous or prolonged physical exertion, emotional stresses and life's complexities are at a minimum. They are called upon suddenly to enter upon a strenuous physical hardening process, an altered mode of living, and to break home ties and make new friends. There is no way of determining whether many of these cases are suitable service material except to give them a trial on active duty. Having completed their preliminary period of basic training they may be assigned to situations requiring considerable responsibility and technical skill. A number of these men fail, not because they are physically defective or lacking in the intellectual equipment with which to cope with their problems, but because they are temperamentally and emotionally inadequate to meet the situation. Under such conditions the psychopath has more difficulty in adjusting himself than has any other type of individual. A man with such a personality usually lacks the perseverance necessary for constant application and continued persistent effort, is not likely to be amenable to discipline, and ordinarily cannot comfortably be assimilated in any part of the service without having a detrimental influence on morale. During peacetime recruiting when a well-trained potential nucleus is the goal, it is questionable if even the constitutionally inferior types are to be accepted, although under all-out wartime mobilization

such individuals and the medium-grade intellectual types may be acceptable if properly classified and utilized in certain assignments within the organization. However, those individuals who lack the stamina, the resourcefulness, or the ability to adjust, whether it be physical, mental, or temperamental must of necessity be separated from the service. These latent defects usually become clinically manifest within from 3 to 6 months under service conditions and disposition can be determined then by bringing the individual concerned before a Board of Medical Survey. In this way those persons who have demonstrated their unfitness for continuation in the service by reason of physical defects, or latent, previously unrecognized illness, are discharged by reason of physical disability whereas those who are maladjusted and inapt by reason of personality defects are discharged because of unsuitability.

This review of the recruit selection system in use by the United States Navy indicates the care with which the enlisted personnel are chosen. The process begins in the civilian communities with selective recruiting under the jurisdiction of the navy recruiting service. It is continued during a conditioning period at the naval training stations where highly trained personnel endeavor to eliminate the unsuitable recruits through careful study and detailed analysis of each individual. Thereafter these men are observed under actual service conditions where those who prove unable to adjust can be detected and removed with a view to returning them to a civilian status. Thus as a result of repeated examinations, thorough study and prolonged observation, only the physically and mentally fit are selected. These

individuals possess the qualities which enable them to carry on under adverse conditions of many types. They possess the perserverance to continue through long weeks and months of training practice and under actual war conditions. Most important of all when the ship which they man meets the supreme test of battle the members of the crew will not be found wanting.

CHAPTER XXIII

MENTAL HYGIENE

Mental hygiene in the Navy may be defined as that branch of psychiatry which is concerned primarily with the prevention of mental disease, and the maintenance of the personnel, both afloat and ashore, at the peak of mental health at all times.

PREVENTION OF MENTAL DISEASE

The prevention of mental disease in the Navy may be conveniently discussed under the following headings: (A) SCREENING METHODS; (B) DETECTION OF MENTAL DISORDERS; (C) ELIMINATION OF THE MENTALLY UNFIT; and (D) SPECIAL PROPHYLACTIC MEASURES.

(A) SCREENING METHODS.

Recruiting office.—Any program for excluding the mentally unfit at the recruiting office should always include: (*a*) Careful selection of personnel assigned to recruiting duty; (*b*) rigid qualifications for enlistment as far as the nervous system is concerned; (*c*) use of a general classification test; (*d*) appraisal of the personal traits of each applicant, and an investigation of his moral character; (*e*) utilization of the records available through the police, schools, employment agencies, hospitals, and mental hygiene clinics in this weeding-out process; and (*f*) assistance of the Red Cross Social Service in obtaining histories and other data.

Training stations.—Screening methods in use at the training station are the following: (*a*) Preliminary psychiatric survey of all incoming recruits; (*b*) detailed study by the psychiatric unit of all recruits suspected of having neurological or mental handicaps; (*c*) psychological examination of recruits by a psychologist whenever indicated to evaluate their abilities and determine their emotional characteristics; and (*d*) inaptitude discharge from the service of all recruits found to be mentally unfit for retention therein.

(B) Detection of Mental Disorders.

Mental deficiency.—Low-grade defectives constitute no particular problem in the recruiting office. The detection of borderline feeblemindedness, however, is often quite difficult. Appropriate questions should be put to the applicant to determine his intellectual capacity. If he has a poor school record, with failure to be promoted in several grades, some degree of mental deficiency should be suspected, and psychometric studies are indicated. The feebleminded recruit is soon spotted at the training station by his inability to understand orders and comply with instructions.

Psychopathic states.—The diagnosis of the psychopathic states in the recruiting office is based on the social history, which is usually not available. An endeavor should be made, therefore, to obtain from the applicant himself any evidence of family conflicts, irregular work record, nomadism, hoboism, traffic accidents, and frequent arrests, all of which are highly suggestive of psychopathy. A few characteristics of the psychopath, such as smugness, evasion, lying, arrogance, a marked

gift of gab, and a tendency to brag over his escapades, may be revealed during the examination. At the training station, the regimentation and rigid discipline tend to bring out latent psychopathic traits which before were not apparent.

Psychoneuroses.—In order to detect the psychoneuroses in the recruiting office, the applicant should be questioned concerning nervous traits and symptoms, past and present. The hysteric is apt to overdramatize, but he usually reacts fairly well to the examination because it is a distinct novelty to him. The obsessive individual may insist upon performing some act in a certain way, or he may answer questions in an indecisive fashion. Anxiety neurosis will reveal itself by unusual sweating, rapid pulse, apprehensive expression, and coarse tremors. Neurasthenia should be suspected if the applicant appears thin and undernourished, weak and fatigued, speaks with an effort, and has a hypotension. The routine at the training station soon produces all sorts of bizarre complaints in recruits with no organic basis, which stamps them as being psychoneurotic.

Schizophrenia.—When we attempt to detect the preschizoid personalities in the recruiting office, we run into difficulty. Very characteristic is a tendency of the applicant to preoccupation with little or no affective response during the entire examination. He may be calm or nervous, show extraordinary reserve, or volunteer unexpected information. Perhaps the most important point in the diagnosis is the sensation of queerness or strangeness which he creates in the examiner. The preschizoid applicant with paranoid trends should also be borne in mind. He is apt to watch closely every

move the medical officer makes, and may reveal his suspicious nature by demanding to know the reason for certain steps in the routine. Physical examination often reveals muscular tensions, mannerisms, cyanotic extremities, dermographia, and hyperactive reflexes. At the training station, the preschizoid recruit is easily detected because of his unusual and erratic behavior. In addition, the social history may reveal a personality change or previous institutional care.

Manic-depressive psychosis.—The future victim of this disorder may possibly show some suggestive clues in the recruiting office which might lead to his exclusion. If in the manic phase, his speech and mode of expression are apt to be jerky and flighty. Distractibility is often evidenced by his interest in irrelevant matters not connected with the examination. Irritability over delays in routine procedures is characteristic, although he will be friendly and jovial most of the time. An applicant in the depressed phase appears solemn and morose, volunteers little information, and answers questions in monosyllables. Physical examination is usually negative. Mood swings and cyclothymic disturbances are quickly brought to the surface at the training station and are not difficult to diagnose.

Epilepsies.—The epilepsies are often overlooked in the recruiting office. The applicant should always be questioned in detail concerning fits, convulsive seizures, spasms, or attacks of unconsciousness. In all probability they will be denied, but the desired information may be obtained in some cases. The classical epileptic is morose, irritable, suspicious, hypochondriacal, egocentric, and hyperreligious. Physical examination may show evidences of old injuries or tongue biting

from previous spells. At the training station, the recruit may have a frank seizure, or his perverse make-up and periods of transitory ill humor will bring him to the attention of the psychiatrist.

(C) Elimination of the Mentally Unfit.

Medical officers, both afloat and ashore, should be constantly on the alert for the appearance of nervous and mental disorders in the personnel of the Navy. These cases can be detected in their incipiency if every medical officer will take the trouble to acquaint himself with the prodromal signs, the early symptoms, and the diagnostic criteria of the neuroses, psychoses, and psycho-somatic conditions. The medical officer aboard ship can often spot those who are maladjusted and likely to break down, by paying particular attention to the frequent visitors to the sickbay, by checking up on the men who are repeatedly up to mast for infractions of discipline, and by talking over personnel problems with chief petty officers and division officers. As soon as a mental disorder is discovered in anyone in the service, he should be evacuated at once to a hospital, and there disposed of in accordance with instructions in the Manual for the Medical Department.

(D) Special Prophylactic Measures.

Heredity.—There has been a tendency to exaggerate the importance of heredity in the cause of mental disease. More often than not when a correct evaluation of the causative factors in the breakdown of an individual has been made, the fault has been found to be in the environment and not in the antecedents. Many measures have been suggested for preventing mental disease by controlling heredity. These include

strict marriage laws, segregation of the mentally incapacitated, birth control, and sterilization. Such methods as these cannot, of course, be applied in the Navy. In connection with this subject, the question often arises as to whether or not a history of insanity in the family is a sufficient cause for rejecting an applicant for enlistment. Generally speaking, if he is normal in every other way, he should be accepted, despite the hereditary taint. On the other hand, if one or both of his parents and several close relatives have been insane, it is wise to reject him even though he is physically perfect.

Childhood.—Perhaps the most important causative factor in the development of mental disease is faulty hygiene during childhood. This is particularly true in schizophrenia, manic-depressive psychosis, and the psychoneuroses. Preventive measures consist in the early recognition of abnormal trends in children, as well as vicious parental attitudes and environmental influences, and in correcting them immediately. This involves à knowledge of child guidance, the psychopathology of childhood, and the problems of adolescence, which we cannot go into here. Very little can be done in the Navy, therefore, to prevent the occurrence of the conditions named above, since prophylaxis to be effective must be instituted before the individual enters the service.

Syphilis.—The prevention of the syphilitic psychoses, notably dementia paralytica and tabo-paresis, depends primarily upon the complete stamping out of lues. Despite personal prophylaxis and the efforts being put forth by various agencies to control venereal infection, the chances are that syphilis will always be

more or less prevalent. Much can be done, however, towards lessening the incidence of its after-effects by early diagnosis, repeated spinal fluid examinations, and adequate treatment in the primary and secondary stages, including malaria combined with chemotherapy.

Alcohol.—Prophylactic measures, as far as the alcoholic psychoses are concerned, consist in the reduction of the amount of alcohol habitually consumed, strict requirements as to the quality of liquor produced and sold, proper diet fortified by vitamins when drinking, and psychotherapy. Much more can be accomplished by a nation-wide educational program than by legislation. In the Navy, it might be helpful for medical officers to give periodic lectures to all hands on the psychological and organic damages resulting from excessive indulgence in alcohol.

Avitaminoses.—No definite correlation has been made between avitaminosis A, C, D, and K, and mental disease in general. Associated with vitamin E deficiency, which produces sterility, there may be feelings of inferiority, symptoms of anxiety, and neurasthenic states. Lack of vitamin B_1 gives rise to a central and peripheral neuronitis, beriberi and Wernicke's disease, with their accompanying mental symptoms. Deficiency in vitamin B_2 causes the psychotic manifestations of pellagra. Measures for the prevention of these conditions, which are rare in the Navy, are simple and obvious.

Trauma.—Neither the traumatic psychoses nor the so-called traumatic neuroses are particularly prevalent in the Navy. These disorders are preventable. Every possible safeguard should be provided for the elimination of accidents and injuries on board ship, at shore

stations, and wherever the men are engaged in hazardous work. Important also is the attitude of the medical officer when treating a patient suffering from a trauma. He should be perfectly frank, and avoid any suggestion that may determine the development of nervous or mental symptoms.

Infections.—Mental disturbances, characterized mainly by delirium, disorientation, motor excitement, and hallucinations, often arise in the course of pneumonia, influenza, malaria, erysipelas, septicemia, cerebrospinal meningitis, and many other febrile diseases. In addition, asthenic and exhaustive states frequently follow in their wake. Prophylaxis depends upon the prevention of the underlying infection, and the proper treatment of the patient, both in the acute stages and during convalescence.

Drugs.—Certain drugs, such as morphine, cocaine, bromides, barbiturates, marihuana, cannabis indica, and others, are apt to cause psychotic manifestations when taken excessively over a long period of time. The habitué undergoes a moral rather than an intellectual deterioration, and he is usually regarded as a degenerate by the community instead of a person who is mentally ill. The only feasible hope for prevention lies in rigid Government supervision and restriction of the habit-forming drugs to the amounts actually needed by physicians. Medical officers in the Navy should be particularly careful in handling and accounting for all narcotics in their custody.

Fatigue.—The true nature of fatigue has not been discovered or elucidated. Its exact relationship to mental illness, which still remains obscure, is a psychiatric problem worthy of intensive study. No matter how

much men may be forced, or how willing they may be to carry on, they become inefficient when subjected to more than a certain amount of fatigue. In fact, as a result of physical and mental exhaustion, they may develop signs of anxiety, insomnia, irritability, loss of appetite, and exaggerated fears. It must be remembered however, that fatigability is a common symptom of practically all the psychoses and neuroses, and not necessarily the cause. The prevention of fatigue is very important. Fighting men must be relieved from their duties, if they are particularly strenuous, at periodic intervals, provided it does not interfere with the military requirements. It is a good plan to remove them from the combat area, if possible, and give them opportunity for relaxation in camps provided for the purpose or elsewhere. It should be emphasized, however, that recreation, diversion, exercise, and psychotherapy are often more effective in combating fatigue than prolonged rest, which is not the panacea it is generally supposed to be.

Maintenance of Mental Health

In discussing measures for maintaining the personnel, both ashore and afloat, at the peak of mental health, we must consider (a) *the Navy as a whole*, (b) *the individual.*

(A) The navy as a whole.

The possibilities of maintaining the mental health of the Navy at a high level are legion. Lessening the strain on the personnel can be accomplished by constantly improving the surroundings and conditions under which the men must live and fight. In other words, all possible physical comforts should be provided and irritating influences removed. Fitness of the

body likewise tends to insure efficiency of the mind. Good food also conditions mental health. In addition, an attempt should be made to place each man in the job which he likes and is best suited for. The psychology of self-preservation and herd instincts, and the various ways of controlling fear, should be explained to the personnel by circulars and lectures systematically prepared. A thorough knowledge of the objectives and principles for which we are fighting, and a firm belief in their attainability, are important aids to the mental health of a fighting Navy. As far as possible, the men should be kept informed about what is going on, the mission of the ship or force, and the plan of battle. This helps to produce a healthy state of mind and esprit de corps in the personnel. Increased facilities for taking care of the families of officers and enlisted men in naval hospitals and dispensaries, expansion of the activities of the Navy Relief Society, frequent and regular deliveries of mail to the fleet and outlying stations, and periodic leave whenever practicable, are all measures that contribute to the morale, and hence the mental health, of all hands.

(B) THE INDIVIDUAL.

The individual in the Navy can improve and maintain his mental health himself by cultivating those habits and thoughts which enable him to make an adequate adjustment to service life. A few suggestions will suffice. The emotions should not be suppressed indefinitely. A natural outlet must be found for them, and they should be controlled by use of the intellect. The many annoying and irritating situations which are constantly arising should be pushed aside without wor-

rying or brooding over them. One of the attributes of a healthy mind is tolerance of the opinions of others. We must also approach the problems that confront us with courage and confidence. This will enable us to solve them easily. To keep the mind in optimum health, one must work and be active. Every person, however, no matter how much he may be absorbed in what he is doing, should have interests outside of his occupation. Recreation and hobbies serve as a mental tonic. Finally, a sense of humor, combined with a cheerful and amiable disposition, dispels distressing thoughts, relieves tension, and keeps us from taking ourselves and life too seriously.

Chapter XXIV

QUARANTINE RULES AND REGULATIONS

It is unlawful for any merchant ship or other vessel from any foreign port or place to enter any port of the United States except in accordance with the provisions of the quarantine laws and the rules and regulations of state and municipal health authorities.

Every vessel subject to quarantine inspection, entering a port of the United States, its possessions or dependencies, is considered to be in quarantine until given free pratique. Such vessel must fly a yellow flag at the fore and observe all the other requirements of vessels actually quarantined.

No person, except the quarantine officer, quarantine employees, or pilots, will be permitted to board any vessel subject to quarantine inspection until after the vessel has been inspected by the quarantine officer and granted free pratique, except with the permission of the quarantine officer, and any person boarding such vessel may, in the discretion of the quarantine officer, be subject to the same restrictions as those imposed on the personnel of the vessel.

Pratique is that freedom of the port which is extended by a certificate, signed by the quarantine officer, to the effect that a vessel has, in all respects, complied with the quarantine laws, and that all on board are free from quarantinable diseases or the danger of conveying the same.

The quarantine laws and regulations of the United States designate the following as quarantinable diseases:

(1) Cholera, period of incubation 1 to 5, usually 3 days.
(2) Yellow fever, period of incubation 3 to 6 days.
(3) Smallpox, period of incubation 8 to 16 days.
(4) Typhus fever, period of incubation 5 to 20 days.
(5) Leprosy; alien lepers are not permitted to land; if a citizen, the case is dealt with according to the State laws of the port of entry.
(6) Plague, period of incubation 3 to 7 days.
(7) Anthrax, period of incubation 7 days.

A ship arriving in the United States with any of these diseases on board will be placed in quarantine.

A *bill of health* is an official document issued by the proper port official at a port of departure concerning principally the sanitary and health conditions in and adjacent to the port. United States bills of health are usually issued by United States consular officers or United States Public Health Service medical officers.

Any vessel clearing from a foreign port for any port or place in the United States must obtain from the consul, vice consul, or other consular officer of the United States at the port of departure, or from the medical officer where such officer has been detailed by the President for that purpose, a bill of health in duplicate, setting forth the sanitary history and condition of the vessel, and that it has in all respects complied with the rules and regulations prescribed for securing the best sanitary condition of the vessel, its cargo, passengers, and crew.

The President, in his discretion, is authorized to detail any medical officer of the Government to the office

of the consul at any foreign port for the purpose of furnishing information and making the inspection and giving the above-mentioned bills of health.

Under the quarantine laws and regulations of the United States every vessel departing from a port in the insular possessions or dependencies of the United States for a port in the United States, is required to take out an American bill of health in duplicate. Inasmuch as there are no American consuls stationed in ports in the insular possessions and dependencies of the United States such bills of health are issued by the quarantine officer on duty in such ports.

The issuance of American bills of health by such quarantine officers is conditioned upon the proper observance of the outbound quarantine requirements prescribed in the quarantine regulations issued by the Public Health Service. Vessels will be given bills of health by the quarantine officer only when such appropriate provisions have been properly observed.

If the quarantine officer is not satisfied that such requirements have been properly observed, and that a vessel may safely enter any port in the United States, its possessions or dependencies, without danger of introducing quarantinable disease, he may refuse to issue a bill of health and in event of departure of the vessel without the required bill of health, may report by cable to the quarantine officer at the port of destination that the vessel has been refused a bill of health and the reasons therefor.

Collectors of customs may refuse entry to vessels from ports in the possessions and dependencies of the United States which fail to present a bill of health,

and remand such vessels to the quarantine station for quarantine inspection and such treatment as may be necessary prior to entry.

These instructions must be observed in the Virgin Islands, Puerto Rico, the Panama Canal Zone, the Hawaiian Islands, and other insular possessions or dependencies of the United States.

Commanding officers of naval vessels, on entering a port, foreign or domestic, are required to comply strictly with all its quarantine regulations. They should afford every facility to visiting health officers and furnish any information they may require. If doubt exists as to the regulations of the port, no communication should be held with the shore, with boats, or with other ships, until a sufficient time has elapsed to allow for the visit of the health officer.

Upon arrival of the ship in port the medical officer should be prepared to receive the health officer and exhibit to him the bill of health; also to answer any questions that may be asked concerning the sanitary condition of the ship.

If a naval vessel arrives in port with a quarantinable disease on board, or such a disease breaks out while lying in port, the fact must be reported at once to the commander in chief or senior officer present. The commanding officer should hoist the quarantine flag and prevent all communication likely to spread the disease elsewhere until pratique is received. In order to check the spread of the disease on board ship, arrangements should be made with the authorities of the port for the care and treatment of the patients on shore or on board

a hulk. If at sea in company with other ships and a quarantinable disease exists or appears on board, the quarantine flag should be kept flying as long as the disease lasts.

By arrangement with the Treasury Department, ships of the Navy to which medical officers are attached are ordinarily exempt from quarantine inspection. A certificate furnished by the ship's medical officer as to the sanitary condition of the vessel and record of communicable diseases may be accepted by the quarantine officer in lieu of actual inspection. In case pratique is granted by radio communication the medical officer upon arrival in port must forward the bill of health in duplicate to the quarantine officer, together with a statement as to sanitary condition, including number of cases of any communicable disease on board. A vessel of the Navy without a medical officer is subject to the provisions of quarantine regulations as they apply to merchant vessels.

Vessels of the United States Navy which carry a medical officer upon entering the United States ports from foreign ports or from ports in the possessions or dependencies of the United States are exempt from quarantine inspection provided that such vessels have not sailed from a port infected with cholera, yellow fever, plague, typhus or smallpox and further provided that no case of these quarantinable diseases has occurred on board en route.

Naval vessels coming within the above provisions will radio to the naval authorities at the port of destination for relay to the quarantine officer, or will radio direct to the quarantine officer, a report of the

pertinent facts, including a statement to the effect that no cases of these quarantinable diseases have occurred on board during the voyage. The radio quarantine message should include an enumeration of the port of departure and all subsequent ports of call on the homeward-bound voyage, together with a statement as to the reported presence or absence of quarantinable diseases in those ports.

Immediately following the arrival of the vessel at the first United States port, the commanding officer should address a letter to the quarantine officer reporting the pertinent facts, including a statement by the ship's medical officer to the effect that no case of the above-mentioned quarantinable diseases occurred on board during the voyage, giving the name and rank of the ship's medical officer, and enclosing duplicate copies of the American bills of health taken out by the vessel at the port of departure and each subsequent port of call on the homeward-bound voyage.

When two or more vessels of the smaller type, such as destroyers, only one of which carries a medical officer, are cruising together, one certificate will be accepted for the quarantine clearance of the group. These provisions do not apply to vessels which do not carry a medical officer or are not certified for by a medical officer as provided in the preceding paragraphs.

Vessels of the United States Navy having entered the harbors of infected ports, but having held no communication which is liable to convey infection, may be exempted from the disinfection and detention imposed on merchant vessels from such ports.

Naval vessels clearing from one United States port for another United States port do not ordinarily pro-

cure a bill of health for presentation at the port of arrival. Local or State authorities at the port of arrival may, however, require the exhibition of a bill of health under special circumstances, such as when some epidemic disease exists at the port of departure, and under such circumstances it is advisable for the medical officer to procure a bill of health.

A naval vessel departing from a port in the continental United States for a port in the Canal Zone or United States possessions is not required to procure a bill of health or port sanitary statement at such port of departure, except when plague, cholera, or yellow fever exist, or typhus fever or smallpox prevail in epidemic form, in the port of departure.

A naval vessel departing from a port in the possessions or dependencies of the United States for a port in the Canal Zone or other United States possessions is required to procure a bill of health in duplicate at each port of departure.

Naval vessels sailing from a United States port to a foreign port should always procure a bill of health from the proper authorities and have it visaed by the consular or other representative of the country or countries of ports of call, if such ports can be determined upon prior to sailing. A naval vessel sailing from a foreign port to another foreign port shall likewise procure and have visaed a bill of health.

The following measures are observed in connection with quarantine inspection and treatment of aircraft of the military forces of the United States:

CLASS I. *In the absence of quarantinable diseases or epidemic conditions at any port of departure or call,* flights of military air-

craft of the United States may be made nonstop to and from the following areas without quarantine restrictions:

United States.	Cuba and Bahama Islands.
Puerto Rico.	(All other islands of the Caribbean area where United States air bases may be established are included.)
Canal Zone.	
Virgin Islands.	
Alaska.	
Canada.	

CLASS II. *Flights having contact with all other areas.*—The officer in charge of the flight should communicate with the quarantine authority in the area where landing is contemplated in ample time to permit this official to be on the field and carry out such procedures as may be indicated.

All personnel on the flight must be confined to the landing field, or to such area as may be designated by the quarantine officer, until released by the quarantine officer.

For the period of the existing national emergency, the Surgeon General of the United States Public Health Service may in his discretion, when requested by the competent military authorities, designate the senior medical officer of an Army or a Navy air base to serve as quarantine officer for the inspection and treatment of military aircraft, carrying only military personnel, which may be proceeding on confidential missions. This delegation of quarantine authority will convey to the military service concerned full responsibility for preventing the introduction into the United States of dangerous communicable diseases and of insect vectors of disease.

Further instructions relative to the quarantine inspection and treatment of aircraft of the military forces of the United States are included in United States Public Health Service Foreign Quarantine Division Circular No. 71, revised December 20, 1941. Due to lack of space it is not possible to include all of these

instructions in this section. Furthermore, some of the instructions apply to wartime measures and are of a temporary nature.

For further information relative to the laws, rules and regulations relating to quarantine and bills of health, attention is invited to chapter 2, title 42, U. S. Code; Code of Federal Regulations and Circulars issued by the Public Health Service; section 1, chapter 40, U. S. Navy Regulations; chapter 18, Manual of the Medical Department, U. S. Navy; and General Orders Nos. 42, 157, and 162.

Chapter XXV

IDENTIFICATION RECORDS

Means of identification are essential. Identification records constitute integral facets in naval service and operation. The advantages of the record system need not be emphasized. By its means identification is prompt, inevitable, and accurate.

To establish beyond a doubt is the purpose of the naval identification system. The identity of the remains of service personnel may hinge on an apparently trivial and insignificant mark noted at the time of enlistment. Consequently instructions for processing the record are minute, and separate directives are issued for the more difficult procedures narrating their proper execution.

Identification records in the naval service consist principally of the general descriptive list and the identification record in the service record, the physical examination record and the health chart, the dental record, the identification card for naval reserves and for civilians, the photo pass card, the identification fingerprint record, the personal identification and enlistment fingerprint card, and the identification tag.

Each of these has a specific purpose and the composite picture that may be garnered from them will describe the general character of the individual and will lead to

his identity either from the summation of parts or from the peculiar characteristic of a part.

Illustrative of this fact, from the dental record alone it may be possible to recognize a service personnel whose remains might have been recovered from the sea or who had been killed in a burning airplane or mutilated by some disfiguring accident.

The forms are prepared for the most part at the time of enlistment or reeinlistment. Some are renewed at enrollment, commission or promotion. Others are added to from time to time with the inclusion of modifying marks or scars, or any change that might alter the description of the service personnel, as for example the extraction of teeth since the last physical examination.

Owing to the urgency of the war, some of the forms are modified as well as parts of their subject matter deleted. For example, it is no longer required to have the identification tags restricted to Monel metal or the fingerprint etched thereon. These directives have been superseded by other instructions more appropriate to the circumstances of war. Any noncorrosive metal may now be substituted for the specific Monel plate.

It is said that Purkinje, the physiologist, was one of the first to call attention to the value of the fingerprint as an identifying record. Unfortunately his suggestion went unheeded until the time of Galton. Now this method is universal.

So important does the Navy look on this means of establishing the identity of its service personnel that a special instruction manual is issued describing the proper technic for making perfect prints. A smuggy, blurred print defeats its purpose, making it difficult or

nearly impossible to discern the characteristics of an impression.

Occasionally circumstances prevail that of their nature make the deciphering of fingerprints a most difficult operation. Bodies for instance lost at sea and recovered will have the skin of the fingertips macerated or greatly shriveled and wrinkled. Treatment must be necessary before satisfactory prints can be made. Water therefore is injected beneath the skin of the fingertips by means of a hypodermic needle smoothing out the skin. Impressions taken in this manner may readily be compared. A blurred original will only add to the complication. Hence the regulation insisting on as nearly perfect fingerprints as possible.

The following are the identifying steps which carry a man into and through the naval service:

1. The descriptive list and identification record in his service record.

2. The physical examination sheet on his health record. This carries a complete record of physical examination on entry, enlistment, or reenlistment, with all identifying marks; and an impression of the right index finger.

3. The dental record. This is another sheet in his health record, carrying all details of condition of teeth as to number, repairs, and replacements.

4. Fingerprint record (identification). This is a Bureau of Naval Personnel form; on one side are spaces for individual and grouped fingers; on the other space for brief data as to name, date, birth, etc., and outlined figure for marking of scars, tattooing, moles, etc.

5. The personal identification and enlistment fingerprint card. This is designed for the purpose of check-

ing on the criminal record of an individual desirous of entering the Navy or Marine Corps. Each applicant for enlistment or reenlistment in the naval service has one of these forms prepared. It is then forwarded to the Federal Bureau of Investigation and not infrequently it leads to the identification and apprehension of individuals with criminal records and others who are undesirable for naval service.

6. Identification tag. This is a small disk of Monel or other corrosion-resistant metal, carrying name, designating number, blood group, and date of last tetanus toxoid inoculation. This is worn in duplicate on the body with a fire-resistant chain or wire.

Chapter XXVI

PROCUREMENT OF MEDICAL AND DENTAL SUPPLIES

The Naval Medical Supply Depot under this title was authorized by Secretary of the Navy Morton, on May 26, 1905, and a building located on Flushing Avenue, Brooklyn, N. Y., within the naval hospital reservation was erected for the purpose. This building was evacuated upon the completion of the present building, the third, at Sands and Pearl Streets, October 15, 1918.

The Naval Medical Supply Depot at San Francisco, Calif., is a development of a small depot formerly located in the Mare Island Navy Yard. During the period 1929 to 1939 this depot's function consisted chiefly of replenishment issues to ships and minor shore stations. With the growth of the Navy the depot storage was expanded but the two-ocean navy soon demonstrated that a large depot and a better location was required. The permanent depot is under construction at Oakland, Calif. In the meantime, the San Francisco depot is in rented facilities.

While the emergency has modified the routine somewhat, the basic function of the Brooklyn Medical Supply Depot is as follows to:

(1) Provide standard medical stores (*a*) for the fleet and outlying shore stations, and (*b*) for shore stations within the United States.

(2) Maintain on hand, in accordance with approved naval policy, such medical stores as may be designated by the Bureau.

(3) Provide facilities for salvage and for repair of medical equipment.

(4) Provide laboratory facilities for examination and testing of medical stores.

(5) Develop and revise material specifications for medical stores and initiate recommendation for revision of Federal, Navy Department, and Bureau specifications when indicated.

(6) Develop logistic data relative to medical stores.

(7) Develop and revise commissioning-outfit lists of material for ships and shore stations.

(8) Recommend modifications in the Supply and Supplementary Supply Tables, annually, October 1.

At San Francisco, Calif.:

(1) Maintain on hand a minimum quantity of each supply-catalog item of medical stores, except perishables, equal to the average annual issues plus such quantities of reserve stores as may be designated by the Bureau.

(2) Establish a maximum quantity of each supply-catalog item of medical stores, except perishables, equal to twice the average annual issues (par. 3148), plus such quantities of reserve stores as may be designated by the Bureau.

(3) Establish a replenishment order point for each supply-catalog item of medical stores, except perishables; the replenishment order point is a quantity consisting of minimum quantity plus a quantity sufficient to meet average issues for the number of months normally required to obtain replenishments.

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(4) Submit normal replenishment requisitions four times annually (following the beginning of each quarter). This procedure should result in replenishment of approximately one-fourth of the items carried, to the maximum quantity, each quarter, and, except for fluctuations in current issues, the replenishment quantities requisitioned should approximate 1 year's average issues. Replenishment quantities shall be adjusted to the nearest case unit, except when such adjustment would exceed 2 months' average issues.

(5) Suitable modification of the foregóing procedure should be made in the case of stores subject to rapid deterioration.

Both the medical supply depots have by reason of the emergency been expanded by adding medical supply storehouses to their existing facilities.

At Brooklyn, they operate subsidiary storehouses at Newport, R. I.; Norfolk, Va.,; Charleston, S. C.; and New Orleans, La.

San Francisco depot operates storehouses at Seattle, Wash.; Long Beach, Calif.; and San Diego, Calif.

The Manual of the Medical Department prescribes the routine for requisitioning material from depots. This is basic. For the emergency certain modifications of the prescribed routine are in effect. Briefly, practically all overseas activities, ashore and afloat, are replenished through the storehouse system and under regulations and routines as prescribed by area commanders.

Within the United States, activities ashore and afloat use the NMS Form 4 requisition (7 copies) system, submitting requisitions direct to Brooklyn or San Francisco as location dictates, except in emergencies when local storehouse if existing, may be utilized.

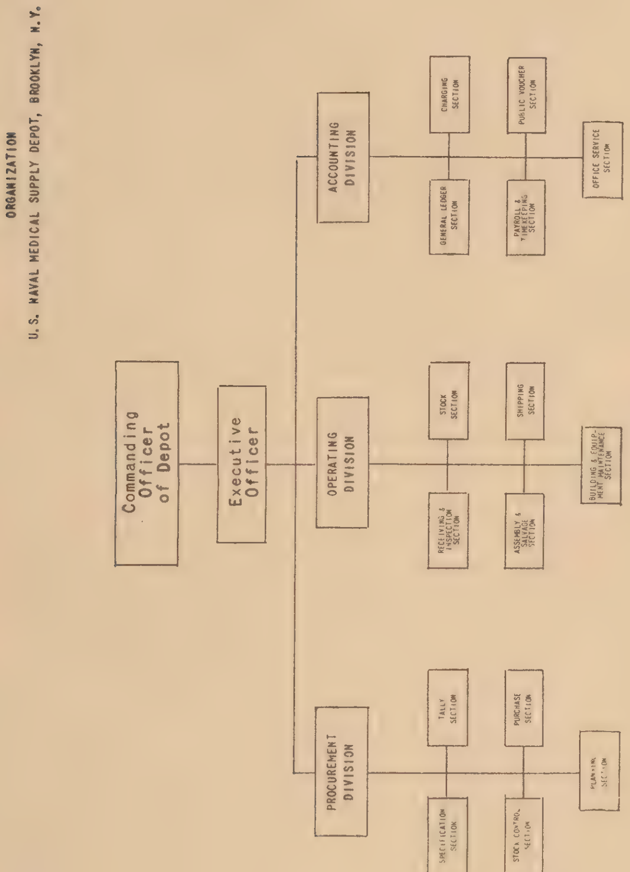
ORGANIZATION
U.S. NAVAL MEDICAL SUPPLY DEPOT, BROOKLYN, N.Y.
Commanding Officer of Depot
Executive Officer
PROCUREMENT DIVISION
SPECIFICATION SECTION
TALLY SECTION
STOCK CONTROL SECTION
PURCHASE SECTION
PLANNING SECTION
OPERATING DIVISION
RECEIVING & INSPECTION SECTION
STOCK SECTION
ASSEMBLY & SALVAGE SECTION
SHIPPING SECTION
BUILDING & EQUIPMENT MAINTENANCE SECTION
ACCOUNTING DIVISION
GENERAL LEDGER SECTION
CHARGING SECTION
PAYROLL & TIMEKEEPING SECTION
PUBLIC VOUCHER SECTION
OFFICE SERVICE SECTION

FIGURE 61.

Wartime expansion may severely tax the capacities of all procurement agencies. Delays in delivery of materials to the depots, even when high priority ratings are assigned, can frequently necessitate (*a*) reduction in quantities requisitioned or (*b*) "transfer requisitions." The failure or inability of some contractors to meet specifications may result in rejection of materials and another waiting period results.

At all times medical department units ashore and afloat can lessen the interval between the date of a requisition and that of receipt of items by careful observance of the following points:

(*a*) By preparing S. D. requisitions in accordance with the references listed above.

(*b*) By paying attention to the necessity of indicating the type and voltage of electric current, proper identification of parts (when required) and the identification of the unit or apparatus, serial numbers, etc., for which the parts are required.

(*c*) By limiting "emergency" requisitions to items and quantities required *immediately* to meet needs until regular or replenishment S. D. requisitions are submitted, particularly when air mail, air express, railway express or other costly method of shipment is required.

(*d*) Bearing in mind transportation difficulties, congestion, and delays, whenever possible units should submit S. D. requisitions well in advance of overhaul or "in port" periods.

(*e*) When possible, replenishment S. D. requisitions should be submitted not less than 2 months in advance of the time material is required, due allowance being made for transit time. If at the time the requisitions are prepared, certain items are desired at an early date,

those items should be listed in a *separate requisition* and an appropriate comment made under "remarks."

(*f*) Requisitions for material such as beds, chairs, bedside lockers, mattresses, overbed tables, x-ray units, and similar major items required to outfit or expand shore stations should be submitted at the earliest possible date and bear a statement as to the tentative date material is desired or *can be received*.

(*g*) Despatch or letter inquiry relative to prospective shipment of material should be limited to *urgently necessary* items. When such communication cannot be avoided, care should be observed to accurately identify the *proper name of the ship or station*, the *S. D. requisition number and date*, the *item number, stock number*, and the *name of the material.*

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